Navigating by Falling Stars: Monetary Policy with Fiscally Driven Natural Rates

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Determination of long-term inflation in the standard New Keynesian framework

- **Taylor rule**:

$$i_t = \overline{r} + \overline{\pi} + \phi(\pi_t - \overline{\pi}).$$

- **Natural Rate**

$$r^* = 1/\beta - 1.$$

- **Long-term inflation determination**: If the central bank sets $\overline{r} = r^*$, then it can achieve its inflation target $\overline{\pi}$.

What happens in a heterogeneous-agent New Keynesian model?

- In a HANK model, the natural rate is a function of the stock of debt B_{ss}: $r^* = r(B_{ss})$.
- Debt-financed fiscal expansions then act as "natural rate" shocks.
- To achieve its target, the central bank must adapt its monetary policy to the long-term fiscal stance $\overline{r} = r(B_{ss})$.
- This is a new form of monetary-fiscal interaction, unrelated to the FTPL.

Preview of findings

1. There is a minimum level of debt compatible with the inflation target.
2. If the central bank does not adapt its monetary policy to a permanent fiscal expansion, then long-term inflation will be higher.
3. In the short-run, inflation can deviate substantially from the target even if the central bank adjusts, due to income effects.
4. Robust monetary policy rules à la Orphanides-Williams perform much better in this environment than Taylor rules.
5. We can infer the *policy gap* between the central bank intercept $\bar{r}$ and the natural rate r^* using market data.

A simple model

Model overview

1. Heterogeneous households
    - Mass 1 of households, subject to idiosyncratic labor productivity shocks.
2. New Keynesian block
    - Unions are similar to intermediate goods producers in a NK model.
    - Sticky wages: they set wages on behalf of workers.
    - Yields a simple wage Phillips curve.
3. Monetary and Fiscal Policy
    - Central bank follows a Taylor rule.
    - Treasury follows does not choose an explosive path for debt.
4. Firms
    - Representative firm with aggregate production function.
    - Flexible prices.

Households

- Households solve:

$$V(a_{i,t}, z_{i,t}) = \max_{c_{i,t}, a_{i,t+1}} u(c_{i,t}) - v(n_{i,t}) + \beta \mathbb{E}_t[V(a_{i,t+1}, z_{i,t+1})]$$

$$\text{s.t.} \;\; c_{i,t} + a_{i,t+1} = (1 + r_t)a_{i,t} + (1 - \tau)\frac{W_t}{P_t} z_{i,t} n_{i,t} + T_t,$$

$$a_{i,t+1} \geq 0.$$

- They choose $c_{i,t}$ and $a_{i,t+1}$. Their labor choice $n_{i,t}$ is is performed by unions.

  - $c_{i,t}$: consumption
  - $n_{i,t}$: working hours
  - $a_{i,t}$: asset position
  - r_t : return of bonds
  - W_t : nominal wage
  - P_t : price level
  - $z_{i,t}$: idiosyncratic productivity
  - T_t : net transfer

Treasury: Fiscal Policy

- The treasury can issue one-period nominal bonds. Tax collection is given by:

$$\mathcal{T}_t = \int_0^1 \tau \frac{W_t}{P_t} z_{i,t} n_{i,t} di.$$

- Public debt B_t accumulates according to:

$$P_t B_t = (1 + i_{t-1}) P_{t-1} B_{t-1} + P_t (G_t + T_t - \mathcal{T}_t).$$

- G_t : government consumption
- $\mathcal{T}_t$: tax collection
- B_t : public debt

Central bank: Monetary Policy

- The central bank follows a Taylor rule:

$$i_t = \max\left\{\bar{r} + \overline{\pi} + \phi_\pi\left(\pi_t - \overline{\pi}\right), 0\right\}.$$

- $\bar{r}$: real rate intercept
- i_t : nominal rate
- $\overline{\pi}$: inflation target
- π_t : inflation

Firm

- Representative firm with linear aggregate production function:

$$Y_t = \Theta N_t.$$

- Flexible prices: $W_t / P_t = \Theta$.

◦ Y_t : output ◦ Θ : constant productivity ◦ N_t : aggregate labor

Unions

- Wage Phillips curve:

$$\log\left(\frac{1+\pi_t^w}{1+\overline{\pi}}\right) = \kappa_w\left[-\frac{\epsilon_w - 1}{\epsilon_w}(1-\tau)\frac{W_t}{P_t}\int u'(c_{it})z_{it}di + v'(N_t)\right]N_t$$
$$+\beta\log\left(\frac{1+\pi_{t+1}^w}{1+\overline{\pi}}\right)$$

- Proportional allocation of labor: $n_{i,t} = N_t$

  - π_t^w : wage inflation
  - N_t : aggregate labor
  - W_t : nominal wage
  - P_t : price level

Aggregation and market clearing

- In equilibrium all agents optimize and the labor, bond, and good markets clear:

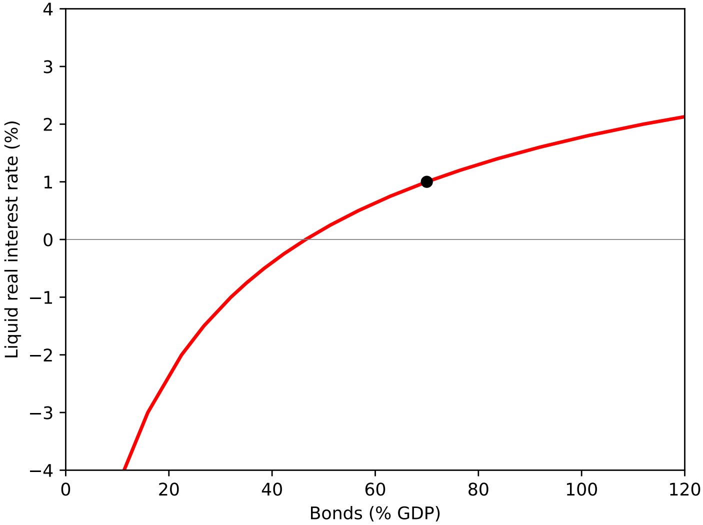
$$G_t + C_t = Y_t,$$
$$A_t = B_t,$$

where aggregates are:

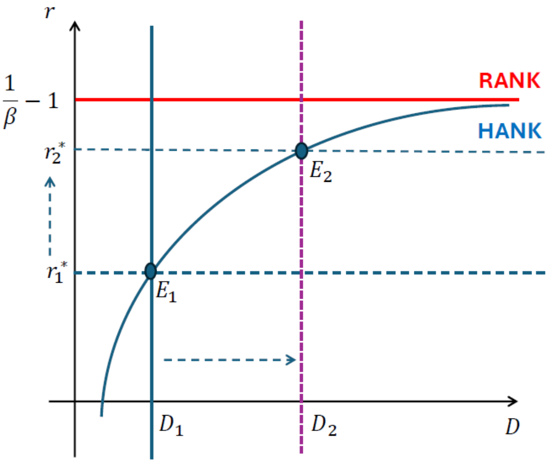
$$N_t = \int_0^1 z_{i,t} n_{i,t} di,$$
$$A_t = \int_0^1 a_{i,t+1} di,$$
$$C_t = \int_0^1 c_{i,t} di.$$

Monetary-fiscal interaction in the long run

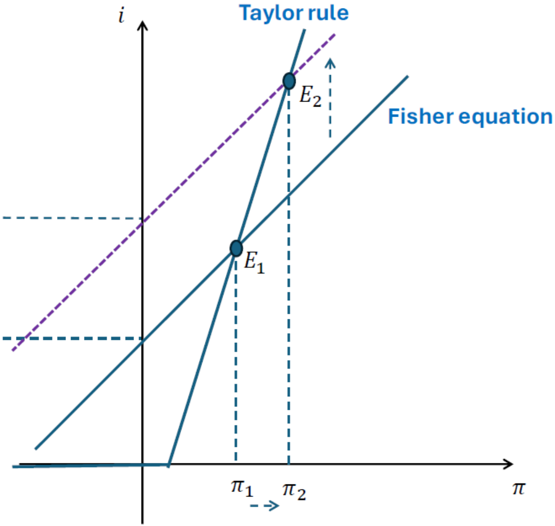
Natural rate determination



The natural rate and long-run inflation



Supply and demand of safe assets



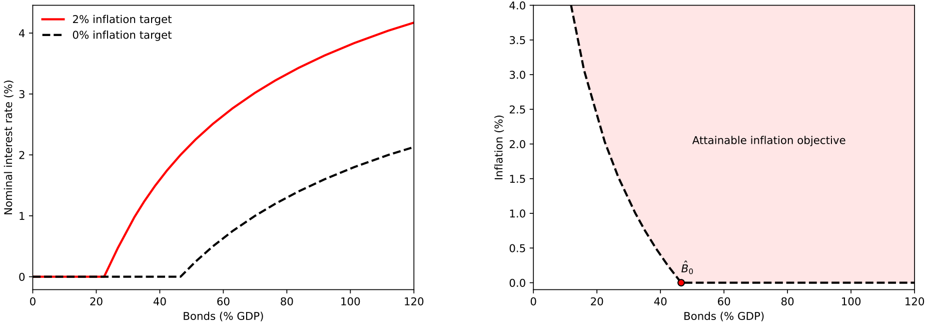
Fisher equation and Taylor rule

The policy gap

The Fisher equation + Taylor Rule imply the following steady-state relationship:

$$\pi_{ss} = \overline{\pi} + \frac{r^* - \overline{r}}{\phi_\pi - 1}.$$

There is a minimum debt level compatible with price stability



Steady-state nominal interest rate and inflation for different inflation targets

Long-run quantitative effects of a fiscal expansion

Description of the exercise

- Calibrate the model to US data (as in the NBER WP).
- Consider an initial steady state with debt at 70% of GDP.
- Compute a new steady state with debt at 80% of (initial) GDP.
- In this new steady state, the treasury chooses a new level of G_{ss} that satisfies debt stability.
- The central bank adjusts $\overline{r}$ in its Taylor rule and sets it equal to value of r^* in the new steady state to avoid inflation above its target in the long run (matters only for nominal variables).

Long term impact

	Initial steady state	New steady state		Difference	
		HANK	RANK	HANK	RANK
Bonds (% GDP)	70.00	80.00	80.00	10.00	10.00
Real interest rate	1.00	1.16	1.00	**0.16**	0.00
Nominal interest rate	3.02	3.19	3.02	0.17	0.00
Output	100.00	99.90	99.96	-0.10	-0.04
Consumption	80.00	80.16	80.07	0.16	0.07
Govt. consumption	20.00	19.74	19.89	-0.26	-0.11
Tax revenue	27.70	27.67	27.69	-0.03	-0.01
Primary surplus (% GDP)	0.70	0.93	0.80	0.23	0.10

Table 1: Steady state in the simple HANK model and in a RANK model

The natural rate r^* increases by 16 bp.

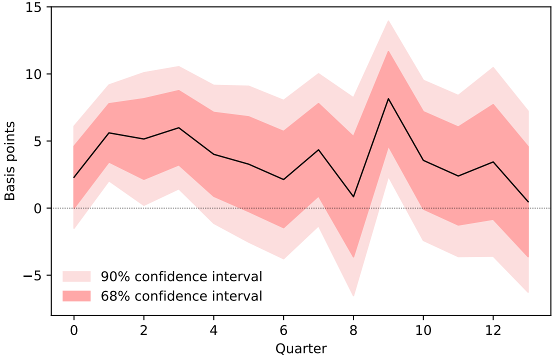
Is the model quantitatively accurate?

- Semi-elasticity:

$$\eta_B \equiv \frac{dr^*}{d\ln B_{ss}} \approx \frac{\Delta r^*}{\Delta \ln B_{ss}} = \frac{0.16}{\ln 0.8 - \ln 0.7} = 1.2$$

- Does this fit the data?

Estimating the response of the natural rate to a permanent increase in debt is quantitatively similar to simulations of the model



IRF of r^* to a 1 pp increase in the government debt-to-GDP ratio

Note: We estimate an LP with $r^*_{t+h} = \alpha_h + \beta_h D_{t-1} + \mathbf{x}_t \gamma_h + u_{t+h}$ and plot the regression coefficient β_h (the solid line) associated with the lagged public debt-to-GDP ratio D_{t-1}. We use the natural rate estimated by Lubik and Matthes (2015) as our measure of r^*. The control variables $\mathbf{x}_t$ include four lags of the change in r^*, three additional lags of the public debt-to-GDP ratio, and four lags of the federal funds rate, the GDP deflator, and the unemployment rate. The shaded areas represent the 68% and 90% confidence intervals using Eicker–Huber–White standard errors.

Empirical evidence

- The point estimate from our empirical exercise is 2.4.
- Summers and Rachel (2019) estimate a semi-elasticity of 2.1.
- Bayer, Born, and Luetticke (2023) also argue in favor of semi-elasticities above 2.
- All of these estimates are well above the semi-elasticity delivered by the simple model when calibrated to US data.
- Next step: construct a quantitative model that matches various aspects of the US economy.

A quantitative model

Changes

- Households have two accounts: one liquid, one illiquid.
- Adjusting illiquid assets is costly (as in the model of Alves, Kaplan, Moll and Violante).
- Liquid assets are invested fully in public debt. This debt has a duration that is longer than one period.
- Illiquid assets are invested full in firm equity.
- We add capital as an input in the production function. Capital is owned by firms.
- It is costly to adjust the capital stock.
- Prices and wages are sticky.
- Firm profits and wages are taxed.
- The Taylor rule has interest rate smoothing.

Households

- Households solve:

$$V(b_{i,t}, a_{i,t}, z_{i,t}) = \max_{c_{i,t}, b_{i,t+1} a_{i,t+1}} u(c_{i,t}) - v(n_{i,t}) + \beta \mathbb{E}_t[V(b_{i,t+1}, a_{i,t+1}, z_{i,t+1})]$$

$$\text{s.t.} \;\; c_{i,t} + b_{i,t+1} + a_{i,t+1} = (1 + r_t^b) b_{i,t} + (1 + r_t^a) a_{i,t} + (1 - \tau_n) \frac{W_t}{P_t} z_{i,t} n_{i,t} + T_t - \Psi(a_{i,t+1}, a_{i,t}),$$

$$b_{i,t+1} \geq 0, \quad a_{i,t+1} \geq 0.$$

- They choose $c_{i,t}$ and $a_{i,t+1}$. Their labor choice $n_{i,t}$ is is performed by unions.

- $c_{i,t}$: consumption
- $n_{i,t}$: working hours
- $b_{i,t}$: liquid assets
- $a_{i,t}$: illiquid assets
- r_t^b : liquid rate
- r_t^a : illiquid rate
- W_t : nominal wage
- P_t : price level
- $z_{i,t}$: idiosyncratic productivity
- T_t : net transfer
- $\Psi(\cdot, \cdot)$: adjustment function

Aggregation and market clearing

- In equilibrium, the labor, liquid asset, illiquid asset, and good markets clear:

$$N_t = \int_0^1 z_{i,t} n_{i,t} di,$$

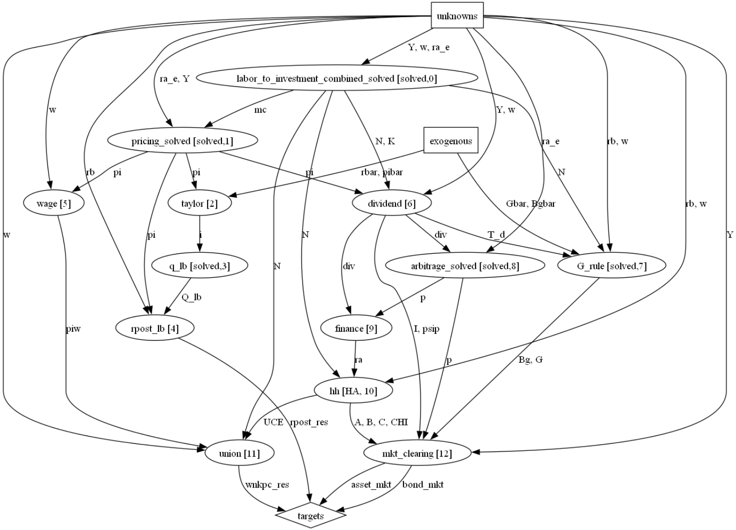
$$B_t = \int_0^1 b_{i,t+1} di,$$

$$p_t = \int_0^1 a_{i,t+1} di,$$

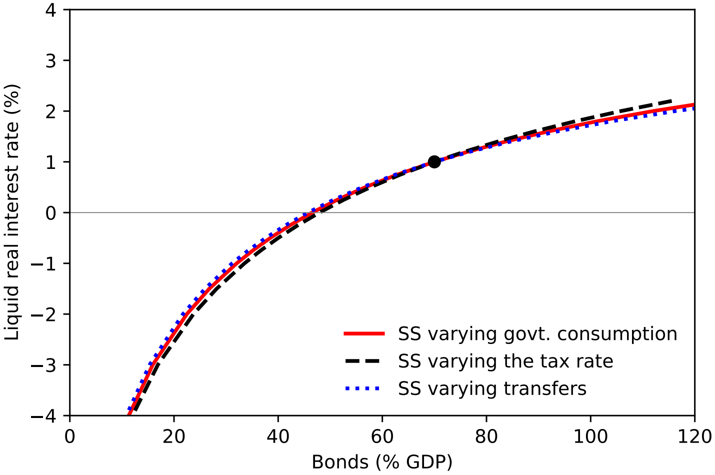
$$C_t = \int_0^1 c_{i,t} di,$$

and the aggregate resource constraint holds: $G_t + C_t + I_t + \xi_t + \Phi_t = Y_t$, where we define aggregate gross investment as $I_t = \zeta(K_t/K_{t-1})K_{t-1} = K_t - (1-\delta)K_{t-1} + \phi(K_t/K_{t-1})K_{t-1}$, so that it includes the cost of adjusting capital.

The full model



Steady states depending on which fiscal variable adjusts

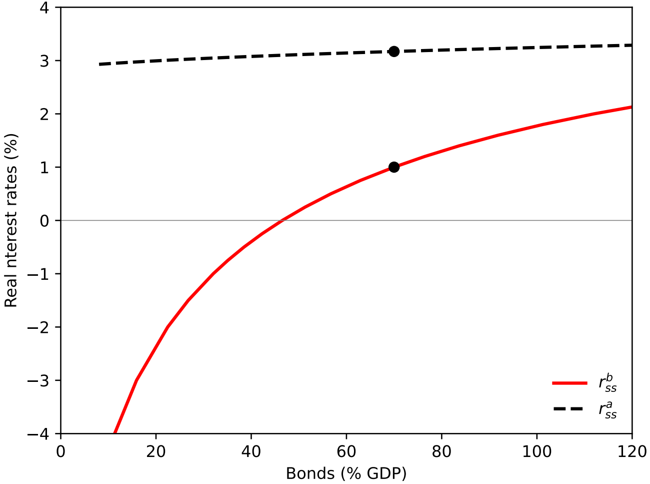


Is the model quantitatively accurate?

- Semi-elasticity:

$$\eta_B \equiv \frac{dr^b_{ss}}{d \ln B_{ss}} \approx \frac{\Delta r^b_{ss}}{\Delta \ln B_{ss}} = \frac{0.31}{\ln 0.8 - \ln 0.7} = 2.3$$

The two interest rates in SS



Alternative fiscal policies in the short run

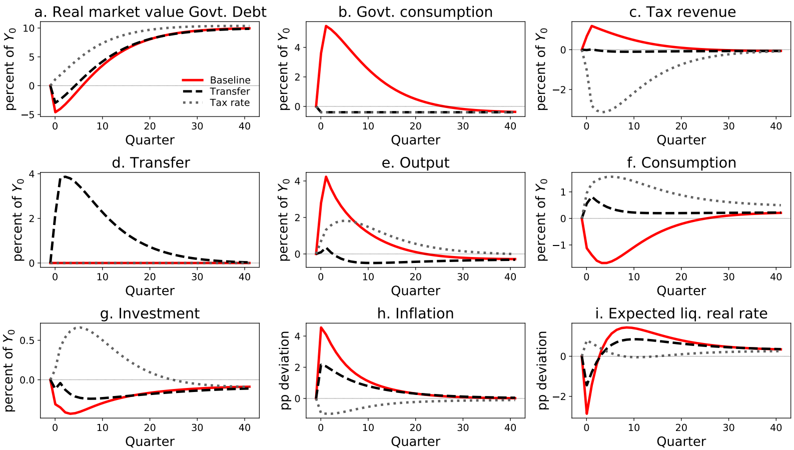
- Government consumption rule
  - The **tax rate** and **net transfers** remain **constant**. The treasury adjusts government consumption G each period according to a rule.

    $$G_t = G_{ss} - \phi_G(B_{t-1} - B_{ss}).$$

- Endogenous tax rate
  - The treasury adjusts the tax rate τ each period so that the evolution of public debt issuance replicates the evolution in our baseline analysis. **Government consumption** jumps to **the new SS value** and **net transfers** remain **constant**.

- Lump-sum net transfers:
  - The treasury adjusts net transfers T each period so that the evolution of public debt issuance replicates the evolution in our baseline analysis. **Government consumption** jumps to **the new SS value** and the **tax rate** remains **constant**.

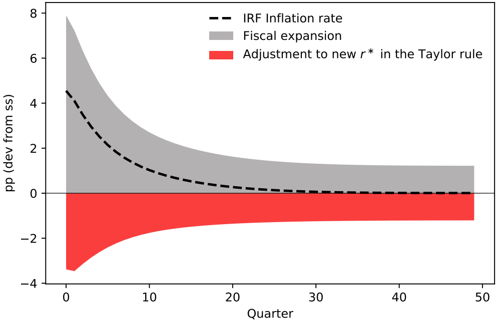
Short term impact



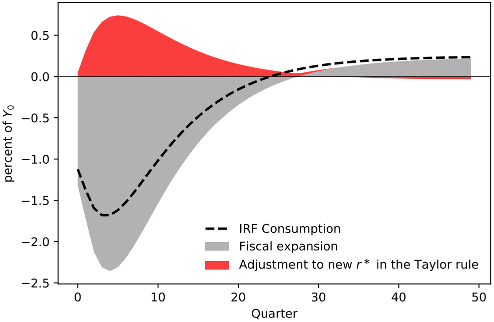
Dynamics after a surprise debt-financed fiscal expansion

Explore the short run when the expansion is due to G

Decomposition of the response of inflation and consumption



Inflation



Consumption

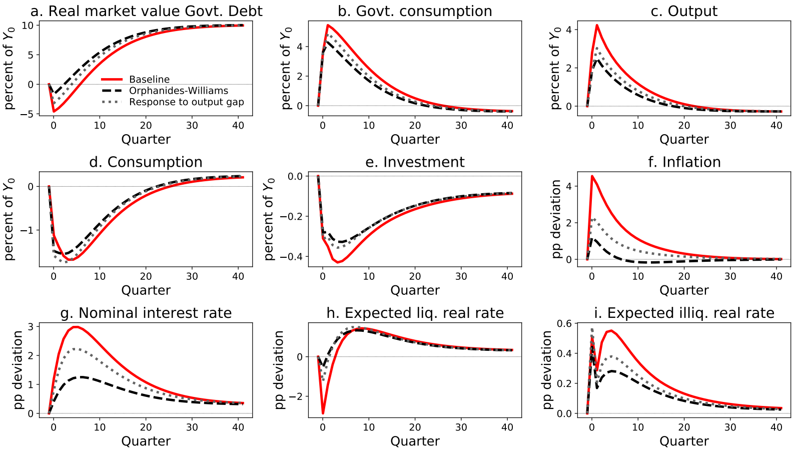
Extensions: Robust monetary rules

- An alternative to adjusting the intercept in the Taylor rule would be to use a monetary policy rule that does not require knowing the value of the natural rate.

- Orphanides and Williams Rule (2002):
  This rule links the **change** in nominal interest rates $i_t - i_{t-1}$ to the deviation of inflation from its target $\pi_t - \overline{\pi}$:

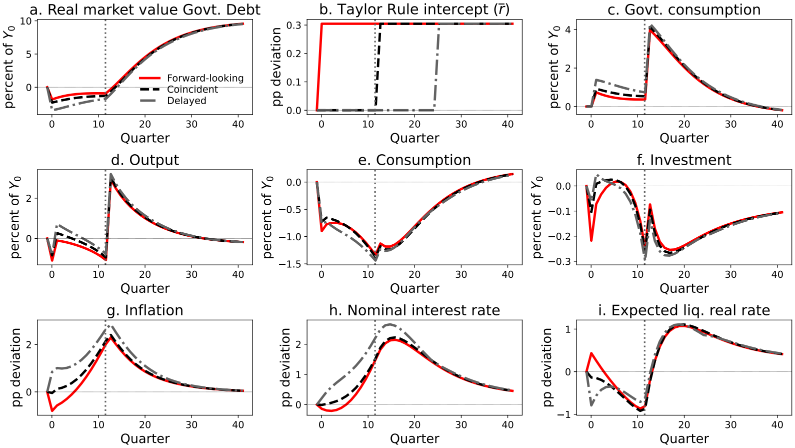
$$\log(1 + i_t) = \log(1 + i_{t-1}) + \phi_\pi \log\left(\frac{1 + \pi_t}{1 + \overline{\pi}}\right)$$

Monetary policy rules



Comparison of different monetary policy rules

Extension: Anticipated effects



Dynamics of an anticipated debt-financed fiscal expansion

The empirical policy gap

Inferring the policy gap from market data

- From the Taylor rule in the DSS and the Fisher equation we obtain:

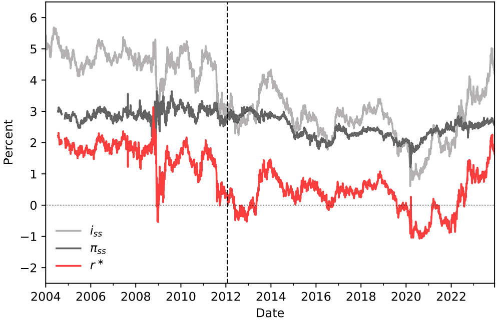
$$\pi_{ss} \approx \overline{\pi} + \frac{r^* - \overline{r}}{\phi_\pi - 1},$$

- If $\overline{r}$ is constant, then the policy gap can be computed as

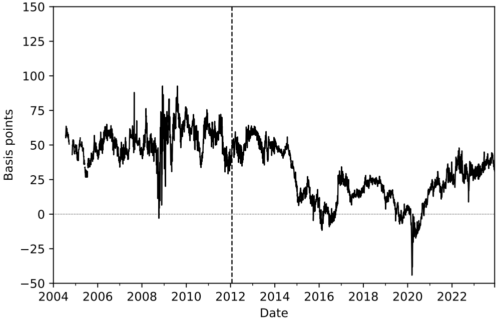
$$r^* - \overline{r} = \frac{cov\left(r^*, \pi_{ss}\right)}{var\left(\pi_{ss}\right)}\left(\pi_{ss} - \overline{\pi}\right).$$

- With this equation we can infer the policy gap from market data.

Inferring the policy gap from market data



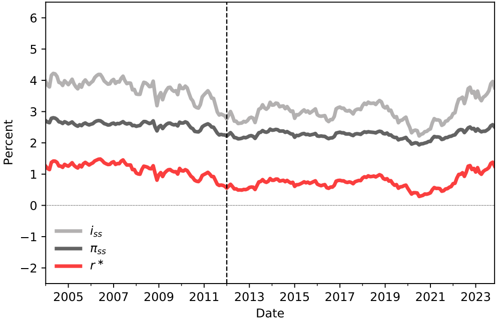
Long-term nominal and real rates and inflation



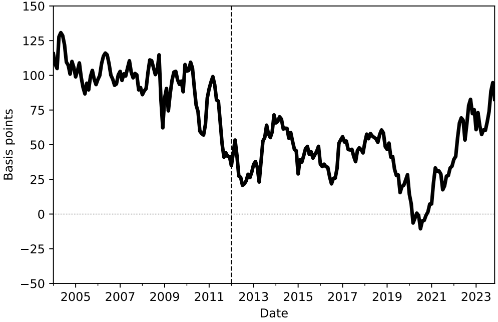
Policy gap $r^* - \bar{r}$

Note: Daily data. i_{ss} is the 5y5y forward nominal rate obtained from the zero-coupon U.S. yield curve. π_{ss} is the 5y5y ILS. r^* is computed as the difference $i_{ss} - \pi_{ss}$. The dashed vertical line marks the date when the 2% inflation target was announced (January 24, 2012).

Correcting for the term premium



Data adjusted for term premia



Policy gap $r^* - \bar{r}$ (adj. data)

Note: Monthly data. The estimated term premia are removed from market data using the methodology described by Hördahl and Tristani (2014). The dashed vertical line marks the date when the 2% inflation target was announced (January 24, 2012).

Thank you!