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 $\overline{B}$: $r^* = r(\overline{B})$.

- 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 $\overline{r} = r(\overline{B})$.

- This is a new form of monetary-fiscal interaction, unrelated to the FTPL.

Preview of findings

- There is a minimum level of debt compatible with the inflation target.
- If the central bank does not adapt its monetary policy to permanent fiscal changes, then long-term inflation will be higher.
- Compared to a RANK model, short-term dynamics are more inflationary even if the central bank adjusts, due to income effects.
- Robust monetary policy rules à la Orphanides-Williams perform much better in this environment than Taylor rules.
- We can infer the *policy gap* between the central bank intercept $\bar{r}$ and the natural rate r^* using market data.

Model

Model overview

1. Heterogeneous households
    - Mass 1 of households, subject to idiosyncratic labor productivity.
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 a fiscal rule.
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:

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

- Fiscal rule:

$$G_t = \overline{G} - \phi_G (B_{t-1} - \overline{B}).$$

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

Central bank: Monetary Policy

- The central bank follows a Taylor rule:

$$\log\left(1+i_t\right) = \max\left\{\log\left(1+\overline{r}\right) + \log\left(1+\overline{\pi}\right) + \phi_\pi \log\left(\frac{1+\pi_t}{1+\overline{\pi}}\right), 0\right\}.$$

- $\overline{r}$: 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:

$$
\begin{aligned}
G_t + C_t &= Y_t, \\
A_t &= B_t,
\end{aligned}
$$

where aggregates are:

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

Calibration

	Parameter	Value	Target/Sources
	Preferences		
σ	Elasticity of intertemporal substitution	1	Standard
φ	Frisch elasticity of labor supply	0.5	Standard
ν_φ	Disutility of labor parameter	0.791	$N_{ss} = 1$
β	Quarterly discount factor	0.992	1% real interest rate in DSS
	Income process		
ρ_e	Persistence income process (annual)	0.91	Floden and Lindé (2001)
σ_e	Std. dev. idiosyncratic shock (annual)	0.92	Floden and Lindé (2001)
	Production		
Y	Quarterly output	1	Normalization
Θ	Constant level of TFP	1	Normalization
κ_w	Slope of the wage Phillips curve	0.1	Aggarwal et al (2023)
ϵ_w	Elasticity of substitution	10	Standard

Calibration

	Parameter	Value	Target/Sources
	Fiscal policy		
r	Real interest rate (annual)	0.01	Baseline case
$\overline{B}$	Debt target	2.8	Debt-to-GDP 70%
$\overline{G}$	Government spending target	0.2	Spending-to-GDP 20%
τ	Tax rate	0.277	Taxes/GDP in 2022
T	Net transfers	0.07	B constant in DSS
ϕ_G	Coefficient in the fiscal rule	0.1	Baseline case
	Monetary policy		
ϕ_π	Taylor rule coefficient	1.25	Standard
$\overline{\pi}$	Inflation target (annual)	0.02	Standard

Monetary-fiscal interaction in the long run

Natural rate determination

- Demand for bonds:

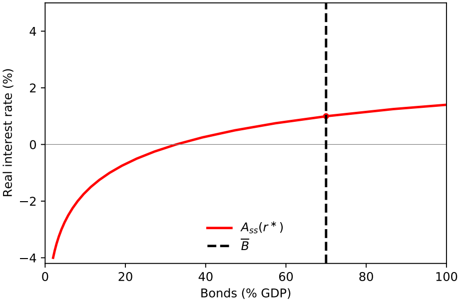
$$A_{ss}\left(r^{*}\right)=\int_{0}^{1}a_{i,t+1}di.$$

- Supply of bonds:

$$B_{ss}=\frac{\left(\overline{G}-G_{ss}\right)}{\phi_{G}}+\overline{B}.$$

- Assume $\phi_G > 1/\beta - 1$; then the supply of bonds is:

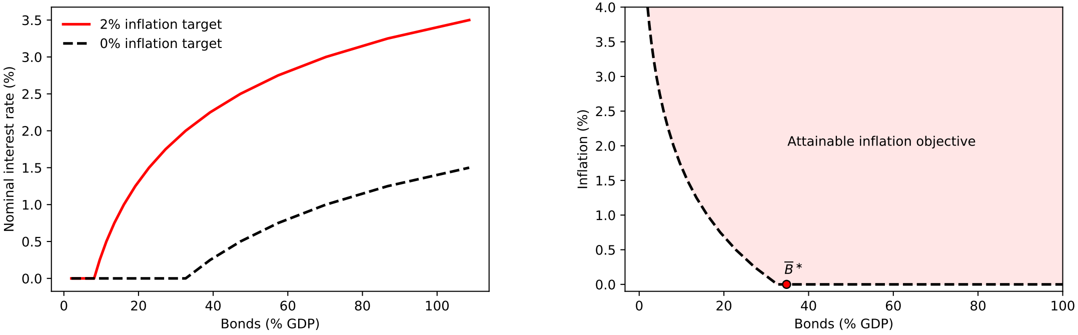
$$B_{ss}=\overline{B}.$$



Deviations from the natural rate in the Taylor rule (policy gap) imply deviations of long-term inflation from the objective

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

There is a minimum debt level compatible with price stability



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

A surprise debt-financed fiscal expansion

Description of the exercise

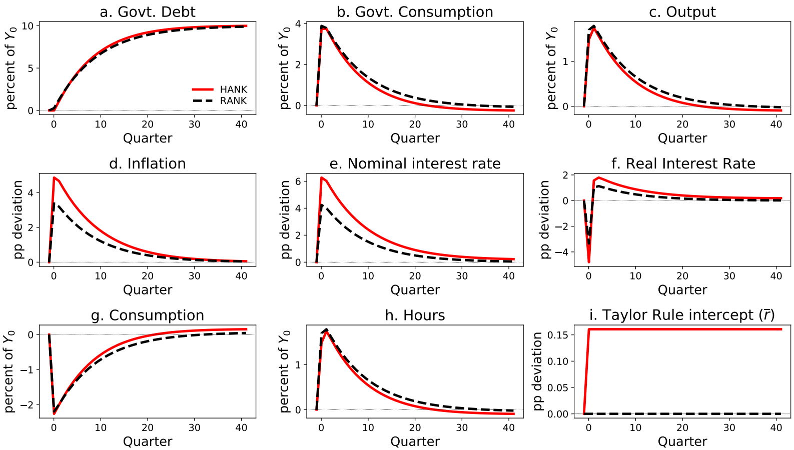
- The economy starts out at a steady state. At $t = 0$ there is a surprise increase in $\overline{B}$ from 70% of GDP to 80% of GDP (MIT shock).
- The fiscal authority lets the fiscal rule do its work, but adjusts $\overline{G}$ to pay for the cost of the additional debt burden (necessary for the existence of a new steady state).
- These changes are common knowledge to all, including the central bank.
- 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.

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

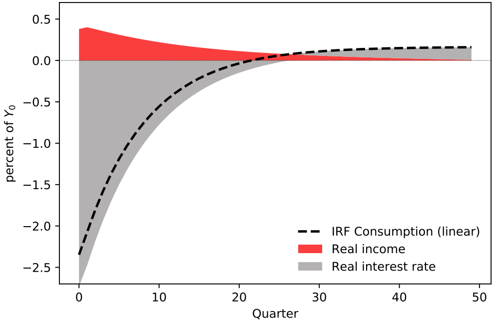
Table 1: Steady state in the baseline HANK model and in the RANK model

Short term impact

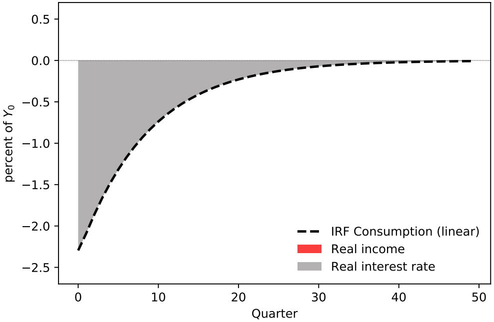


Dynamics after a surprise debt-financed fiscal expansion

Decomposition of the response of aggregate consumption



HANK model



RANK model

Heterogeneity and inflation

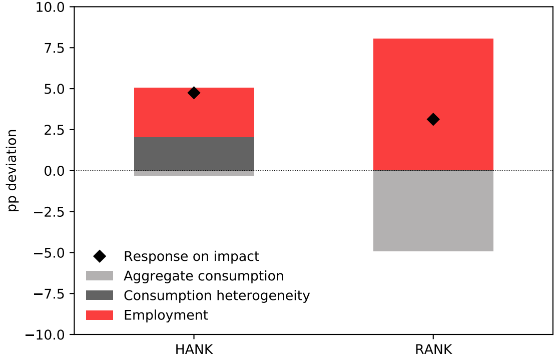
- Expressing the Wage Phillips curve as an infinite discounted sum:

$$\log\left(\frac{1+\pi_0}{1+\overline{\pi}}\right) = \sum_{t=0}^{\infty} \beta^t \kappa_w \left[-\frac{(\epsilon_w - 1)}{\epsilon_w}(1-\tau)\int u'(c_{i,t}) z_{it}\, di + v'(N_t)\right] N_t.$$

  - $\int u'(c_{i,t}) z_{it} di$: cross-sectional average of marginal utilities
  - $v'(N_t)$: labor disutility
  - N_t: hours worked or employment

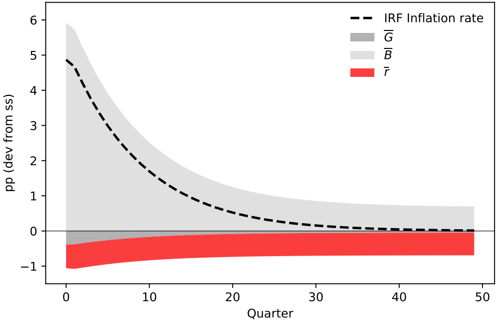
Heterogeneity and inflation

- Decomposition of the response of inflation on impact:

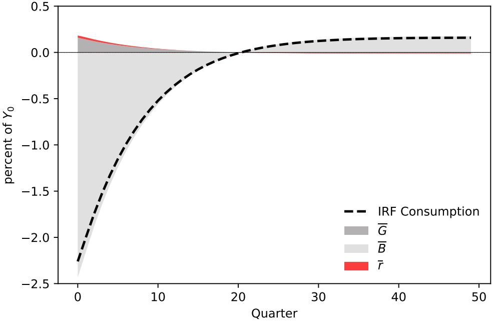


  - $\int u'(c_{i,t}) z_{it} di - u'(C_t)$: consumption heterogeneity measure

Decomposition of the response of inflation and consumption in terms of policy variables



Inflation



Consumption

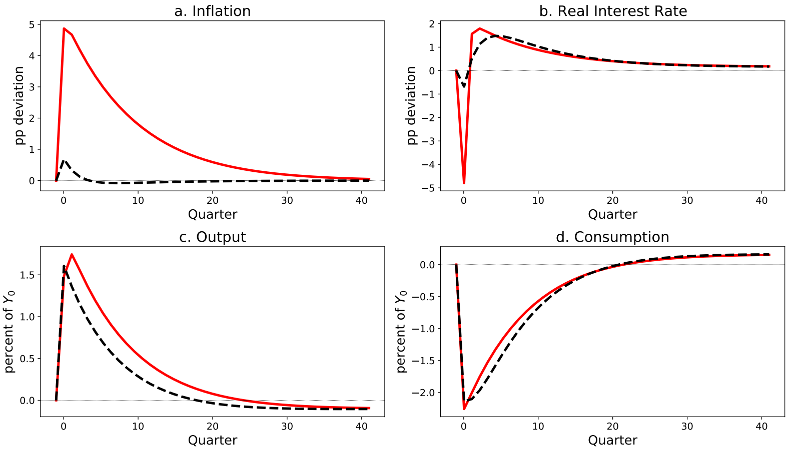
Extensions: Robust monetary rules

- 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 $\pi_t - \overline{\pi}$:

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

Extensions: Robust monetary rules

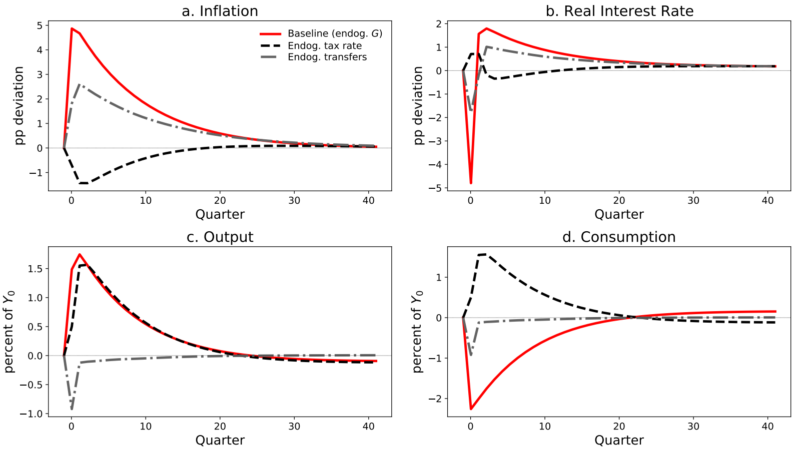


Comparison of a standard Taylor Rule and Orphanides-Williams Rule in the HANK model

Extensions: Alternative fiscal policies

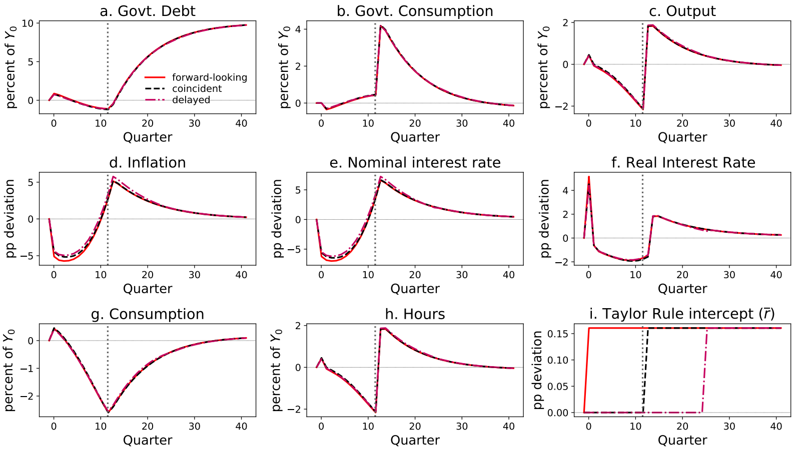
- Endogenous tax rate
  - **Government consumption** and **net transfers** remain **constant**. The treasury adjusts the tax rate τ each period so that the evolution of public debt replicates the evolution in our baseline analysis.
- Lump-sum net transfers:
  - **Government consumption** and the **tax rate** remain **constant**. The treasury adjusts net transfers each period so that the evolution of public debt replicates the evolution in our baseline analysis.

Extensions: Alternative fiscal policies



Dynamics after a surprise debt-financed fiscal expansion

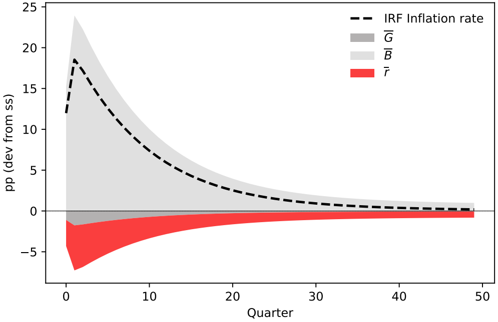
Extensions: Anticipated effects



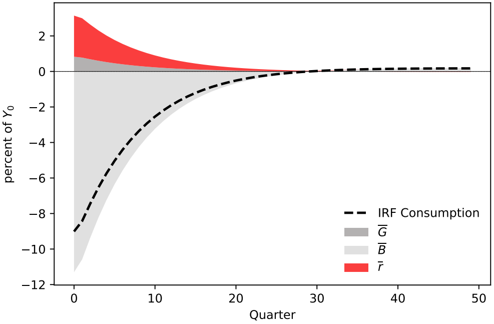
Dynamics of an anticipated debt-financed fiscal expansion

Extensions: A model with long-term debt

Decomposition of the response of inflation and consumption in terms of policy variables



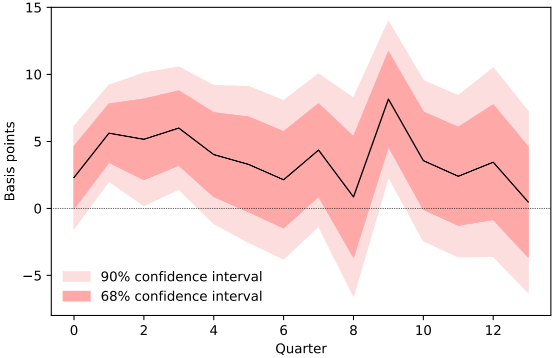
Inflation



Consumption

Validating evidence and the policy gap

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.

Inferring the policy gap from market data

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

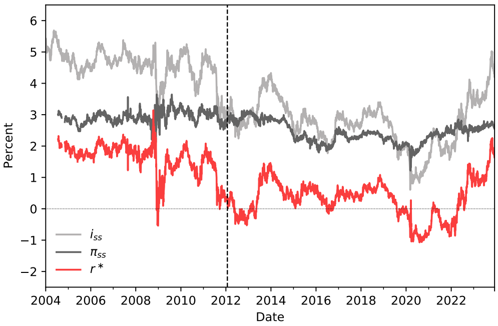
$$\pi_{ss} \approx \overline{\pi} + \frac{r^* - \overline{r}}{\phi_\pi - 1},$$

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

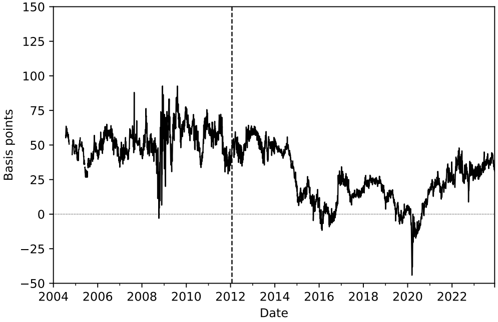
$$r^* - \overline{r} = \frac{cov\left(r^*, \pi_{ss}\right)}{var\left(\pi_{ss}\right)}\left(\pi_{ss} - \overline{\pi}\right).$$

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

Inferring the policy gap from market data



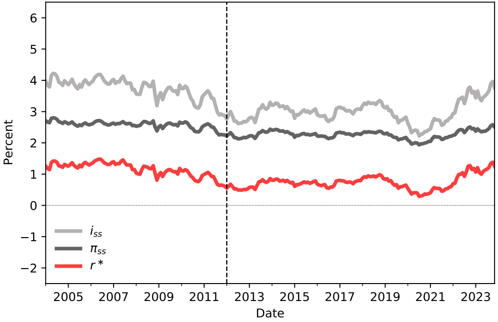
Long-term nominal and real rates and inflation



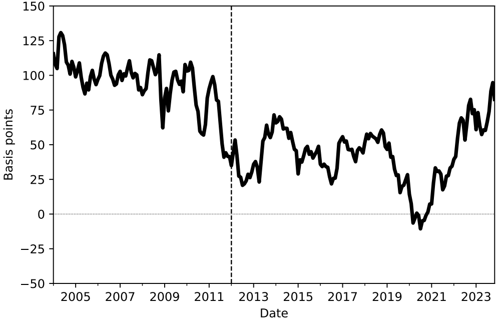
Policy gap $r^* - \bar{r}$

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

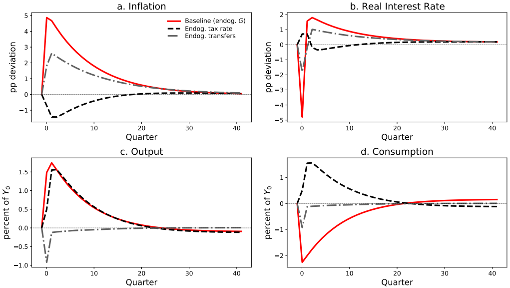


Policy gap $r^* - \bar{r}$ (adj. data)

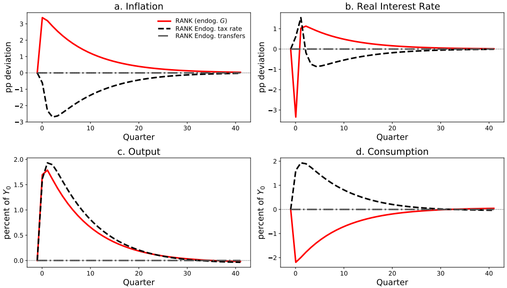
Note: Monthly data. The estimated term premia are removed from market data using the methodology described by Hördahl and Tristani (2014). The dashed vertical line marks the date when the 2% inflation target was announced (January 24, 2012).

Thank you!

Alternative fiscal policies: comparison with the RANK model

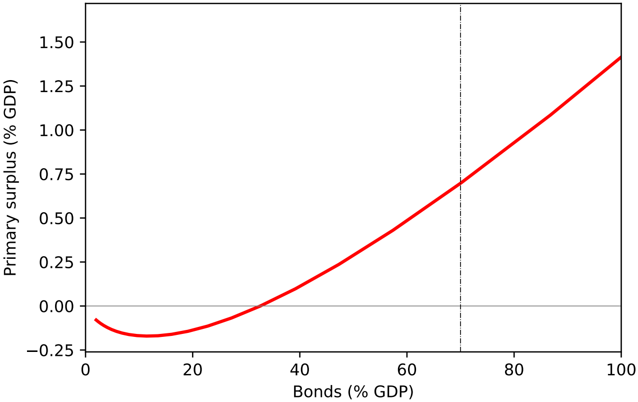


HANK



RANK

Fiscal surplus in different steady states



Fiscal surplus