

# Beyond Averages

## Heterogeneous Effects of Monetary Policy in a HANK Model for the Euro Area

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IMAEF Conference, June 2026

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- Heterogeneous-agent models have become a core part of modern macroeconomics
  - In particular Heterogeneous-Agent New Keynesian models (HANK)
- What do HANK models add relative to representative-agent models (RANK)?
  - Heterogeneity (or inequality) itself
  - Different transmission channels of policies and aggregate dynamics

## Open question

What is the role of HANK models for forecasting and policy analysis in central banks?

- **Build and estimate a medium-scale HANK model for the euro area**
- Use the model in two policy-relevant applications:
  1. Study **alternative monetary policy scenario** around the early 2020s inflationary episode
    - What would have happened if the ECB had tightened earlier?
    - What would have been the distributional consequences?
  1. Contrast **out-of-sample forecasting accuracy** in comparable HANK and RANK models

### Monetary policy counterfactual

- Earlier tightening would have had only **moderate effects on inflation**
  - but **stronger effects on consumption at the bottom** of the wealth distribution,
  - which our model suggests was **already lagging** following the COVID shock
- **Why?** We decompose monetary transmission along the wealth distribution:
  - at the **bottom**, the effect runs mostly through **labor income**;
  - at the **top**, mostly through **asset prices**

### Forecasting: HANK vs. RANK

- HANK and RANK display **almost identical** out-of-sample forecasting accuracy – notably for **aggregate consumption**, where the two models differ most.
- Their forecasts are also **very highly correlated**.

1. **An estimated HANK model for the euro area**
  - Two-asset households, sticky prices and wages, estimated on euro area data
2. **An alternative monetary policy scenario** during the recent inflation episode
  - What if the ECB had tightened earlier — and who would have borne the cost?
3. **Forecasting with HANK and RANK**
  - A like-for-like out-of-sample comparison
4. **Takeaways**

# An Estimated HANK Model for the Euro Area

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- **Households** supply labor, consume, and save in **liquid and illiquid assets**
- **Financial intermediary** holds firm equity and government bonds, supplies assets to households
- **Firms** produce and invest subject to adjustment costs
- **Nominal rigidities** in the form of sticky prices and wages
- **Fiscal authority** taxes households to spend and service debt
- **Monetary authority** follows a Taylor rule

- Households have preferences over consumption  $c_{it}$  and labor  $n_{it}$ :

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t \exp(-\varepsilon_t^C) [u(c_{i,t}) - v(n_{i,t})].$$

- Households save in illiquid assets  $a_{it}$  and liquid assets  $b_{it}$ :

$$a_{it} + b_{it} + c_{it} = e_{it} + (1 + r_t^a)a_{i,t-1} + (1 + r_t^b)b_{i,t-1}, \quad a_{it}, b_{it} \geq 0.$$

- With probability  $\chi$ , households can rebalance portfolios; otherwise  $a_{it} = (1 + r_t^a)a_{i,t-1}$
- Labor income is  $e_{it} = (1 - \tau_t)w_t n_t z_{it}$
- Information frictions:** households update their information about aggregates only with probability  $1 - \theta^C$  each period (sticky information; Auclert–Rognlie–Straub, 2020)
  - Generates **hump-shaped** aggregate consumption dynamics

## Financial intermediary

- The financial intermediary (mutual fund) holds two long-duration assets:
  - Firm equity, with real price given by:

$$p_t^e = \mathbb{E}_t \frac{d_{t+1} + p_{t+1}^e}{1 + r_{t+1}},$$

- Government bonds, with nominal price given by:

$$P_t^g = \frac{1 + \rho^{bonds} \mathbb{E}_t P_{t+1}^g}{1 + i_t}.$$

- It supplies liquid and illiquid assets to households
  - **Liquid assets** are zero-duration liabilities, similar to bank deposits
  - **Illiquid assets** are claims on the financial intermediary's equity
- Long-duration assets generate a **substantial capital-gains channel** of monetary policy
  - A surprise rate change revalues them sharply on impact
  - The capital gain/loss falls on the **illiquid (equity) claim**

- Intermediate-goods producers have production function

$$Y_t = \exp(\varepsilon_t^Z) Z K_t^\alpha N_t^{1-\alpha} - \Phi$$

- Capital-goods producers own the capital stock  $K_t$ , rented at  $r_t^K$
- They maximize profits

$$\mathbb{E}_t \sum_{s \geq 0} \frac{1}{R_{t,t+s}} (r_{t+s}^K K_{t+s} - I_{t+s})$$

- subject to investment adjustment costs

$$K_{t+1} = (1 - \delta)K_t + I_t \left[ 1 - \frac{1}{2} \gamma^I \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \exp(\varepsilon_t^I)$$

- **Monopolistically competitive final-goods producers** set prices à la Calvo, with indexation
- This generates a standard Phillips curve

$$\pi_t - \iota^p \pi_{t-1} = \frac{1}{1+r} \mathbb{E}_t(\pi_{t+1} - \iota^p \pi_t) + \kappa^p \widehat{mc}_t + \varepsilon_t^p$$

- **Unions** face an analogous problem when determining nominal wages
- The wage Phillips curve is

$$\pi_t^w - \iota^w \pi_{t-1}^w = \beta \mathbb{E}_t(\pi_{t+1}^w - \iota^w \pi_t^w) + \kappa^w \widehat{\mu}_t^w + \varepsilon_t^w$$

- Fiscal authority adjusts labor taxes to stabilize public debt:

$$\tau_t = \tau + \phi^B \frac{B_{t-1}^g - B^g}{Y}.$$

- Government consumption follows an exogenous process:

$$G_t = G + Y \varepsilon_t^G.$$

- Monetary policy follows a Taylor rule:

$$i_t = \phi^i i_{t-1} + (1 - \phi^i) (i + \phi^\pi \pi_t) + \phi^{\Delta y} \frac{Y_t - Y_{t-1}}{Y_{t-1}} + \varepsilon_t^i.$$

- Calibrate household balance sheets using HFCS data:
  - Total household wealth: 285% of annual GDP
  - Liquid wealth: 45% of annual GDP
  - Government bond holdings: 50% of annual GDP
- Match an average quarterly MPC of 0.20
- Wealth distribution (**untargeted**) compared to Distributional Wealth Accounts:

Wealth share / statistic	Model	Data (2024 Q1)
Top 5%	31.3	44.3
Next 5%	16.1	13.0
Bottom 50%	6.3	5.1
Gini coefficient	0.66	0.72

## Estimation

- Estimate remaining dynamic parameters: Phillips curves, Taylor rule, shock processes, information stickiness
- Eight euro area time series: real GDP, consumption, investment, government consumption, HICP inflation, wages, total hours, short-term interest rate
- Seven shocks: monetary, price markup, wage markup, investment, consumption, government spending, TFP
- Measurement error on GDP
- Sample: 2000Q1–2019Q4
- Solution method: Sequence Space Jacobian
- Posterior sampled with a **parallel multi-proposal Metropolis–Hastings** (Calderhead, 2014)

An Alternative Scenario for Monetary  
Policy During the Recent Inflation  
Episode

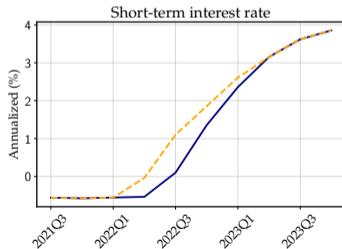
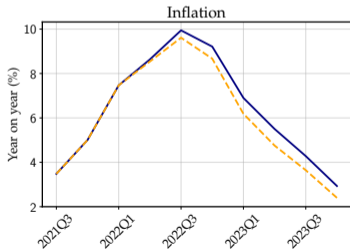
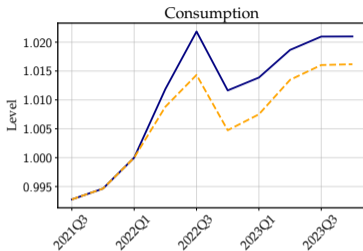
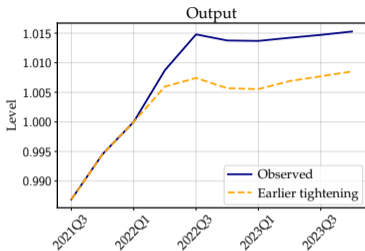
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- What would have happened if the ECB had tightened rates earlier?

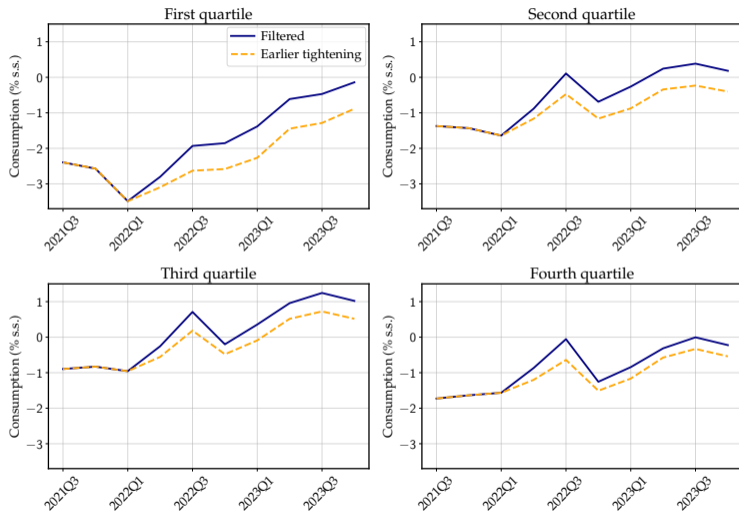
### Scenario

- Policy rates start rising **one quarter earlier**, in 2022Q2
- Rates remain **above the observed path** until 2023Q1
- Rates return to the observed path in 2023Q2
- Back out sequence of monetary shocks that implement alternative path

# Policy counterfactuals: aggregate variables



# Distributional consequences: stronger effect at the bottom



## Intuition: transmission channels

- Following a perfect foresight shock, consumption is given by

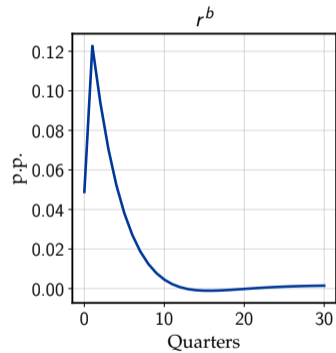
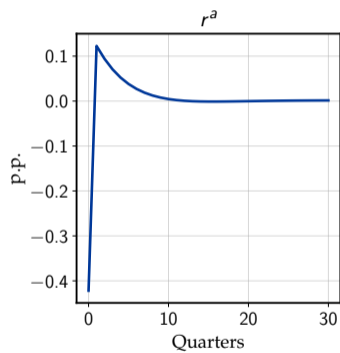
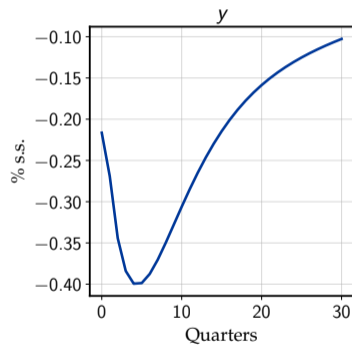
$$C_t = \mathcal{C}_t (\{y_s, r_s^b, r_s^a\}_{s=0}^{\infty}).$$

- $y_t = (1 - \tau_t)w_t n_t$  is disposable labor income;  $r^a$  and  $r^b$  are illiquid and liquid returns
- First-order decomposition:

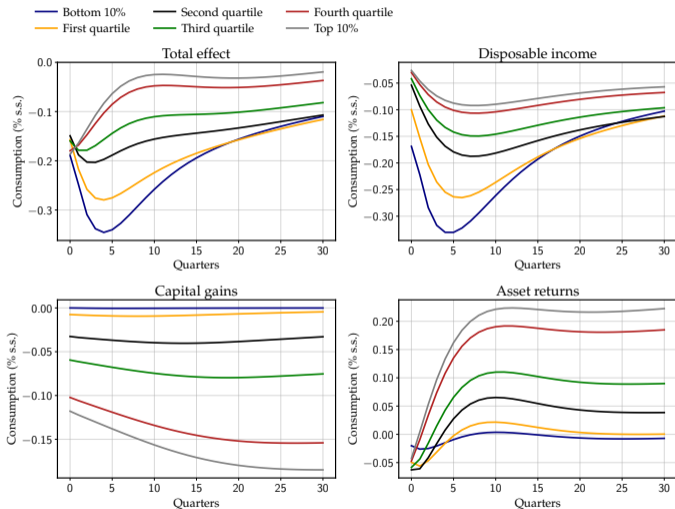
$$dC_t = \underbrace{\sum_{s \geq 0} \frac{\partial C_t}{\partial y_s} dy_s}_{\text{disposable income}} + \underbrace{\frac{\partial C_t}{\partial r_0^a} dr_0^a + \frac{\partial C_t}{\partial r_0^b} dr_0^b}_{\text{unexpected capital gains}} + \underbrace{\sum_{s \geq 1} \left( \frac{\partial C_t}{\partial r_s^a} dr_s^a + \frac{\partial C_t}{\partial r_s^b} dr_s^b \right)}_{\text{expected asset returns}}$$

- Similar to Kaplan, Moll & Violante (2018) and Auclert, Rognlie & Straub (2020), but with:
  - **Different channels**
  - Tracking the effects **across the wealth distribution**

## Transmission channels of monetary policy



# Transmission channels across the wealth distribution



## Forecasting with HANK and RANK

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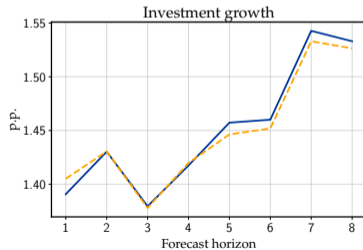
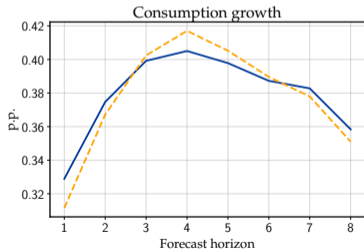
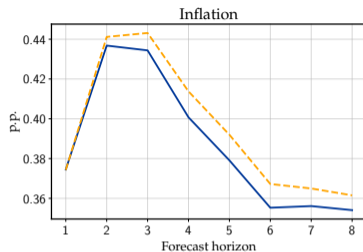
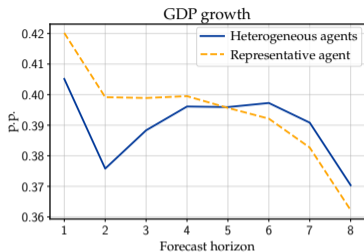
## How do HANK and RANK compare in out-of-sample forecasts?

- To isolate the role of heterogeneity, keep both models **as similar as possible**
- **Replace only the household block** with a representative agent:

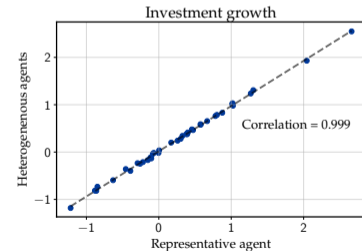
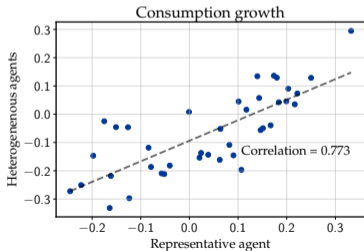
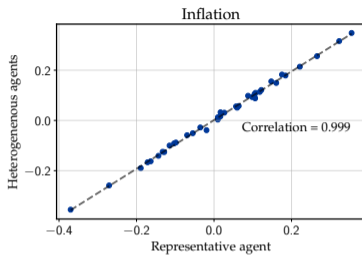
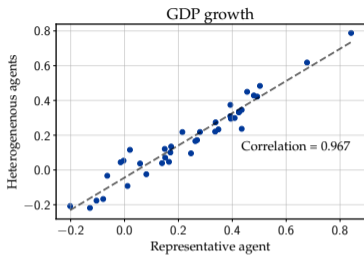
$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t \exp(-\varepsilon_t^C) [u(C_t - hC_{t-1}) - v(N_t)].$$

- **Estimate both models** using the same data and priors on the first half of the sample (2000Q1–2009Q4)
- Compute RMSEs of out-of-sample forecasts for the remaining sample (2010Q1–2019Q4)
- Forecasts are generated at the posterior mode

# HANK and RANK perform similarly in forecast accuracy



# Forecasts are highly correlated in both models



## Takeaways

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- An earlier tightening would have hit the **bottom of the wealth distribution** more strongly
  - Why? Labor markets are a strong transmission channel for these households
- RANK and HANK perform **almost identically** in out-of-sample forecasting accuracy

### What is the role of HANK models for forecasting and policy analysis in central banks?

- HANK adds a **distributional dimension** to policy analysis,
- without giving up aggregate forecasting performance relative to RANK.

## Appendix

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## Appendix: calibrated parameters

Parameter	Description	Value
$\varphi$	Labor disutility curvature	2
$\beta$	Discount factor	0.985
$r^a$	Return on illiquid assets	1%
$r^b$	Return on liquid assets	-0.09%
$\chi$	Probability of accessing illiquid assets	11.9%
$B^g/Y$	Government debt	50%
$G/Y$	Government spending	20.9%
$\tau$	Labor income tax	33.1%

## Appendix: estimated parameters

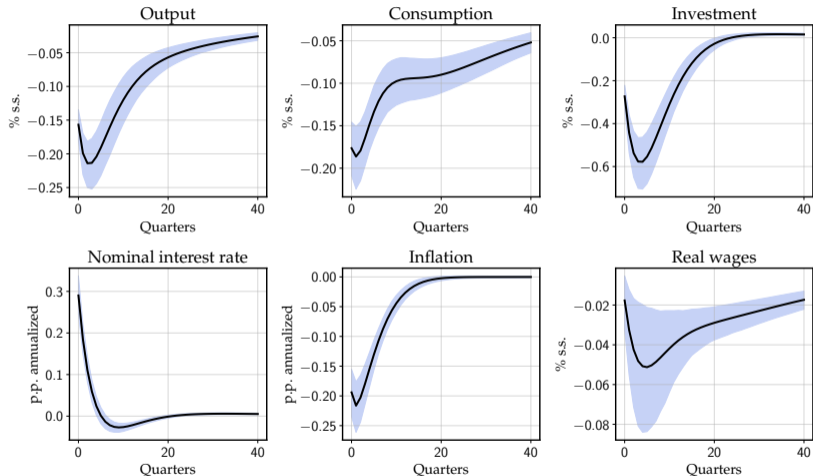
Parameter	Description	Prior	Mode	10–90%
$\theta^C$	Information stickiness	Beta(0.5, 0.10)	0.79	[0.71, 0.85]
$\kappa^P$	Price Phillips-curve slope	Gamma(0.05, 0.015)	0.045	[0.034, 0.068]
$\kappa^w$	Wage Phillips-curve slope	Beta(0.05, 0.015)	0.014	[0.009, 0.024]
$\iota^P$	Price indexation	Beta(0.5, 0.15)	0.16	[0.10, 0.29]
$\iota^w$	Wage indexation	Beta(0.5, 0.15)	0.19	[0.12, 0.33]
$\gamma^I$	Investment adjustment cost	Normal(4, 1)	4.4	[3.6, 5.7]
$\phi^i$	Taylor rule: smoothing	Beta(0.7, 0.05)	0.89	[0.86, 0.90]
$\phi^\pi$	Taylor rule: inflation	Normal(2, 0.1)	1.85	[1.72, 1.97]
$\phi^{\Delta y}$	Taylor rule: output growth	Normal(0.05, 0.05)	0.14	[0.12, 0.17]

## Appendix: estimated shock processes

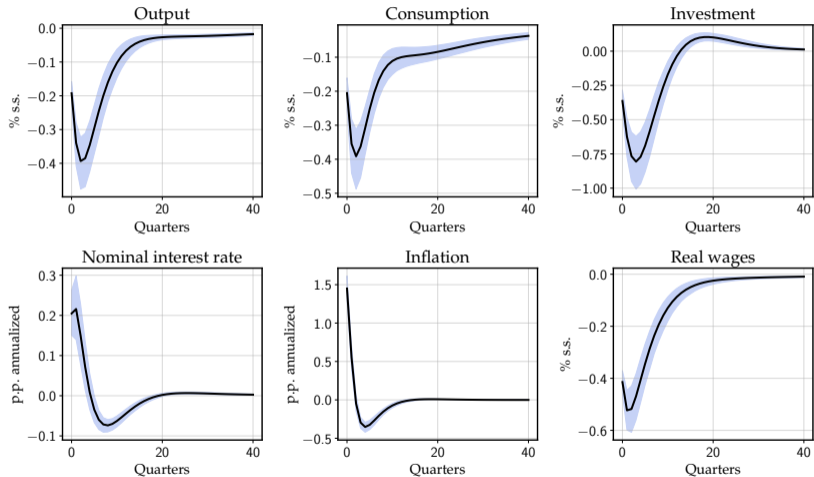
Shock	Persistence $\rho$	Std. dev. $\sigma$
Consumption $\varepsilon^C$	0.89	0.15
Investment $\varepsilon^I$	0.59	3.7
Government $\varepsilon^G$	0.93	0.079
TFP $\varepsilon^Z$	0.85	0.30
Price markup $\varepsilon^P$	0.46	0.30
Wage markup $\varepsilon^w$	0.74	0.20
Monetary $\varepsilon^i$	– (i.i.d.)	0.10

*Common priors:  $\rho \sim \text{Beta}(0.5, 0.1)$ ,  $\sigma \sim \text{Inverse-Gamma}(0.1, 2)$ .*

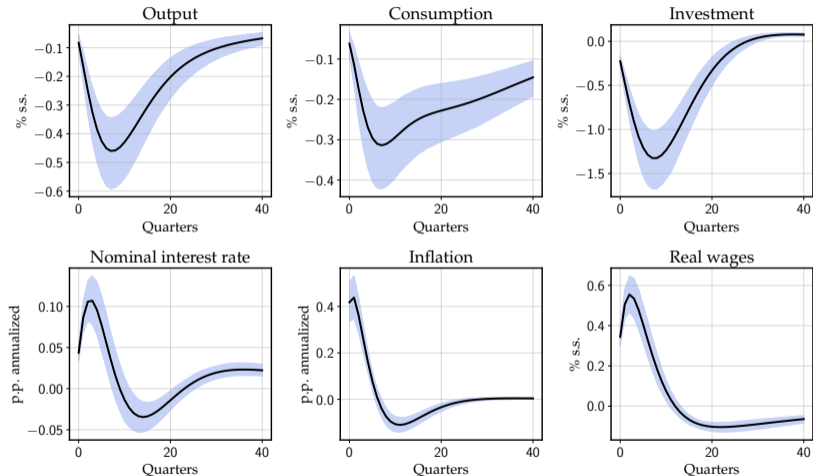
## Appendix: monetary shock



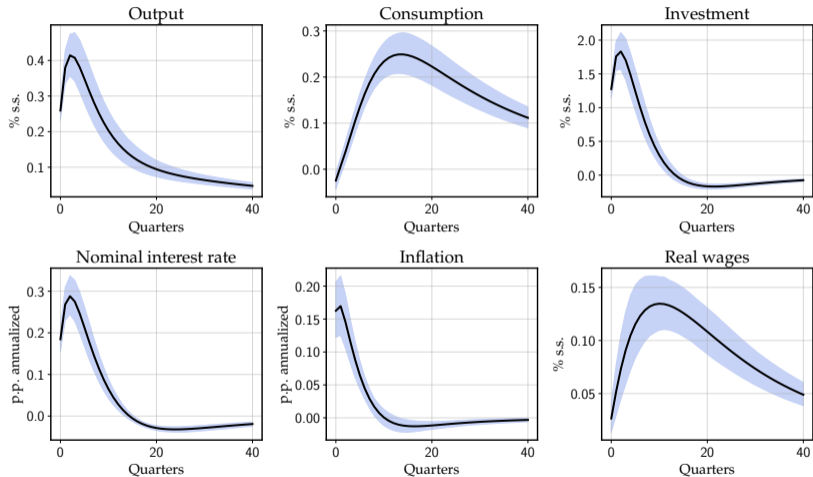
## Appendix: price markup shock



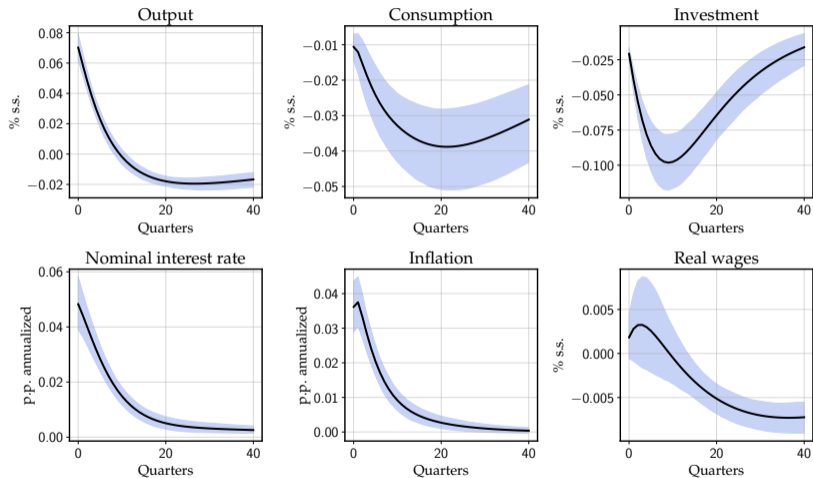
## Appendix: wage markup shock



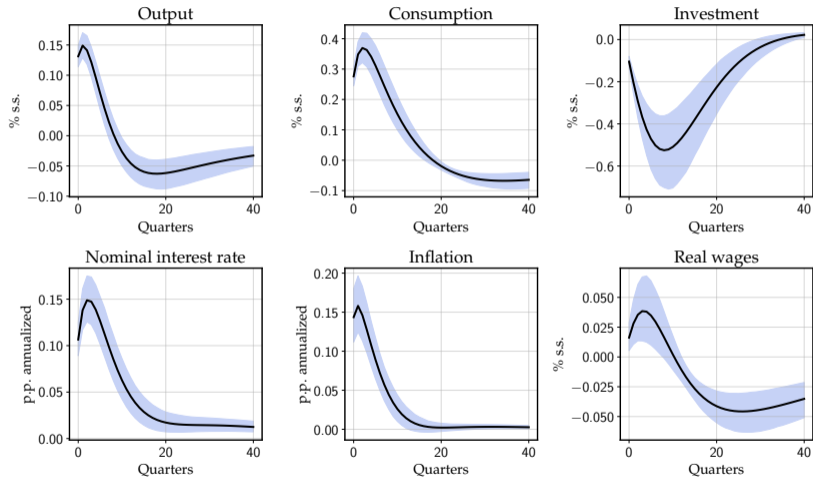
## Appendix: investment technology shock



## Appendix: government spending shock



## Appendix: consumption shock



## Appendix: TFP shock

