Energy price shocks, monetary policy and inequality

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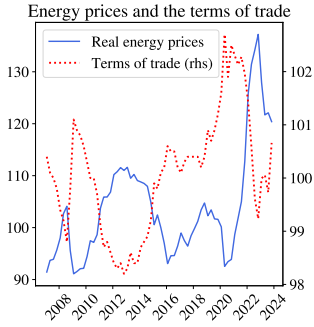
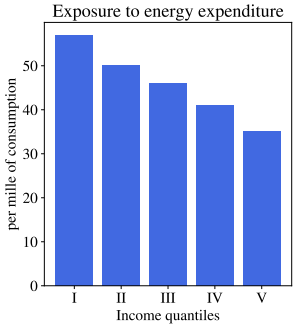
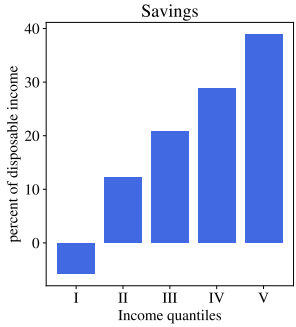
Motivation

Energy price surge and household heterogeneity







- Energy price surge and simultaneous deterioration of terms of trade
- Households are heterogeneously exposed through consumption basket, savings and income source
- Monetary policy strongly reacted despite exogenous shock

Preview of results

Open economy HA (inequality) NK (nominal) model with energy

- Imported energy used for consumption and production
- Heterogeneous households with non-homothetic preferences
- Rigid nominal wages, flexible prices, monetary policy follows interest rate rule

Aggregate effects

- Energy price shocks are always contractionary irrespective of policy
- Active monetary policy raising real rates amplifies adverse effects
- Forecast rule can mitigate aggregate outcomes if sufficiently passive

Distributional effects

- Less wealthy households are more strongly affected
- Consumption decline of less wealthy mostly through declining labor income
- Active policy rules amplify negative labor income response for low-wealth households, incentivize wealthy households to save more

Related literature

Representative agent models with oil price shocks

- **Open economy:** Mendoza (1995), Kose (2002), Catao, Chang (2010), Bodenstein, Erceg, Gust (2011), Baqaee, Farhi (2019)
- **Monetary policy:** Bernanke, Gertler, Watson (1997), Bodenstein, Erceg, Guerrieri (2008), Natal (2012), Gertler, Gagliardone (2023)

Open economy heterogeneous agent models

- Zhou (2020), Auclert, Rognlie, Souchier, Straub (2020), Guntin, Ottonello, Perez (2020), de Ferra, Mitman, Romei (2020), Otten (2021), Oskolkov (2022)

(Limited) heterogeneity and energy shocks

- Pieroni (2023), Chan, Diz, Kannegiesser (2023), Gorneman, Hildebrand, Kuester (2023), Auclert, Monnery, Rognlie, Straub (2023) Olivi et al (2024), Audzei, Sutoris (2024)

Model

Overview

Households ◂ HH

- Non-homothetic preferences
  - Domestic vs energy consumption
- Uninsurable idiosyncratic income risk
  - Save in a mutual fund
  - Ad-hoc debt limit
- Labour supply is demand determined

Labour market ◂ LM

- Unions and labor packer
  - Combine household labour to specific tasks
  - Set nominal wages subject to pricing friction

Mutual Fund ◂ MF

- Unconstrained, risk-neutral
- Portfolio composed of shares in intermediate firms, nominal domestic and foreign bonds

Goods market ◂ Firms

- Final goods producer
  - Combines intermediate input goods
  - Sells to domestic and foreign households
- Intermediate-good producers
  - Produces using labor and energy input

Monetary policy ◂ MP

- Reacts to contemporaneous or forecast measures of inflation
- Baseline: constant real rate

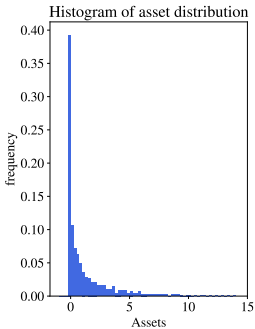
Energy price shock ◂ MC

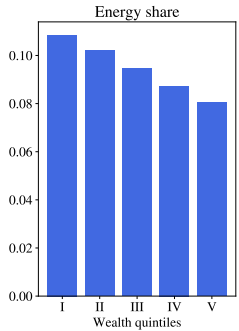
- 30% increase in foreign price of energy

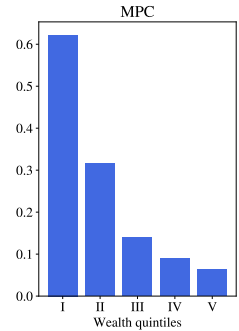
Calibration

Parameter	Definition	Value	Source/Target
Households			
β	Household discount factor	0.968	Annual nominal rate 2%
σ	Household risk aversion	1	Literature
α_h	Energy share in consumption	0.051	Eurostat $c_e/c = 0.09$
$\underline{c}$	Subsistence level energy consumption	0.037	Eurostat $c_e^{Q1}/c^{Q1} = 0.13$
η	Elasticity of substitution consumption	0.4	Bachmann et al. (2022)
φ	Inverse Frisch elasticity	2	Literature
ψ	Utility weight of labor	0.543	$\pi = 0$
Labor Unions			
ε_w	Elasticity of substitution labor	19	Wage markup of 5%
χ	Wage adjustment cost	190	NKPC slope of 0.1
Firms			
α_f	Energy share in production	0.201	Eurostat $E = 0.16$
θ	Elasticity of substitution production	0.5	Acurio (2015)
$\mathscr{M}$	Price markup	1.01	Carroll et al. (2017) MPC $= 0.32$
World Trade			
C^*	Foreign demand level	0.181	$NX = 0$
λ	Foreign demand elasticity	1/3	Auclert et al (2021)

Steady state







- $\sim$ 20% of households are financially constrained
- Half of all households have very little savings
- Lowest wealth quintile spends 3 pp more on energy

Aggregate effects of energy price shock

Contemporaneous monetary policy rules

Energy price shocks are contractionary

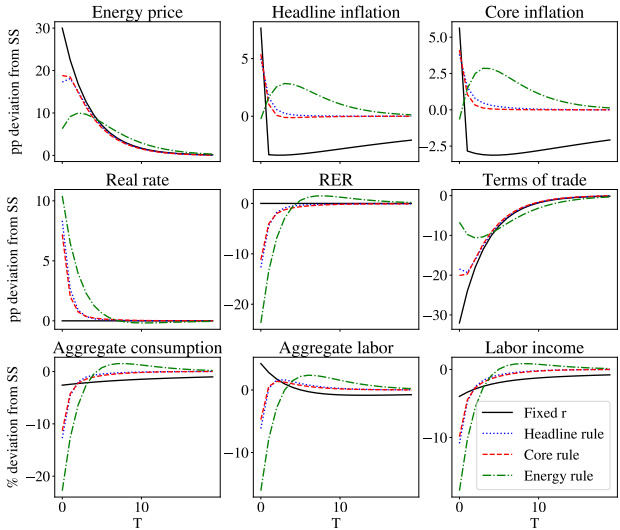
- Aggregate consumption declines independently of the policy rule
- Wealth transfer to foreign economy

Transmission under neutral policy

- Constant real rate does not incentivize saving over consumption
- High pass-through to prices lowers real wages
- ToT decline raises foreign demand

Active policy amplifies aggregate outcomes

- Strong increase in real rate



RANK | Closed economy | Supply shocks

Aggregate effects of energy price shock

Forecast monetary policy rules

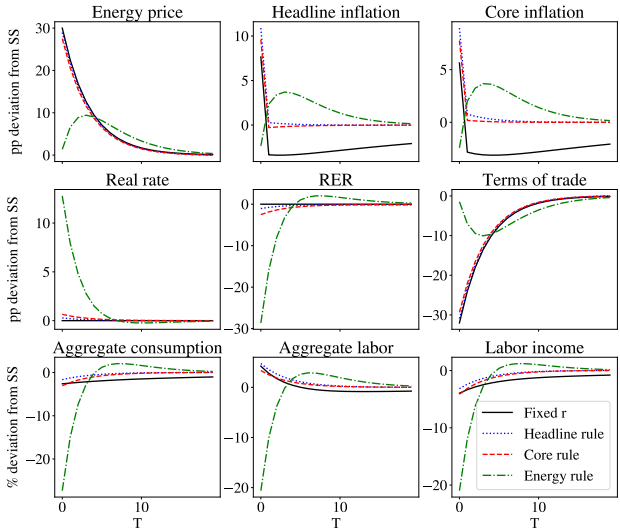
Forecast rule can mitigate adverse effects

- Strongly muted real rate response under headline/core rule

Responding to energy prices directly has substantial recessionary effects

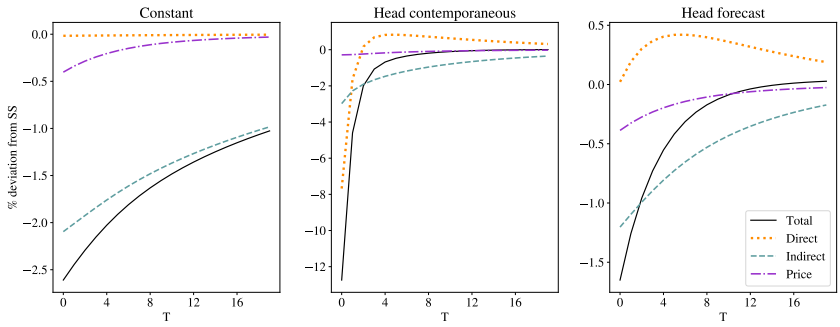
- Initial suppression of inflation through strong decline in aggregate demand
- Resurfacing inflation in the medium-term

▸ Hump-shaped shock



Consumption decomposition

$$dC_t(\{r_t, w_t, N_t, p_{et}\}) = \underbrace{\sum_{s=0}^{\infty} \frac{\partial C_{t+s}}{\partial r_{t+s}} dr_{t+s}}_{\text{direct effect}} + \underbrace{\sum_{s=0}^{\infty} \frac{\partial C_{t+s}}{\partial w_{t+s}} dw_{t+s} + \frac{\partial C_{t+s}}{\partial N_{t+s}} dN_{t+s}}_{\text{indirect effect}} + \underbrace{\sum_{s=0}^{\infty} \frac{\partial C_{t+s}}{\partial p_{et+s}} dp_{et+s}}_{\text{price effect}}$$



- Key drivers of aggregate consumption response differ starkly across monetary policy rules

Distributional effects of energy price shock

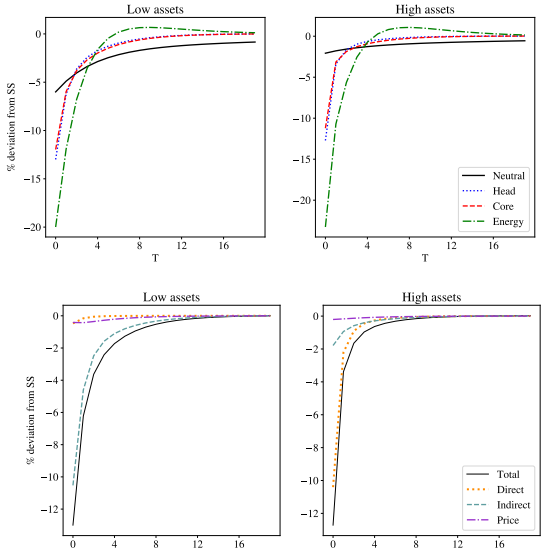
Consumption response and decomposition low- vs high-wealth

Low-wealth households have largest consumption decline

- Under neutral rule stronger consumption decline for less wealthy
- Only under very high real rate increase do wealthy consume less

Different drivers of consumption decline between low- and high-wealth households

- Low-wealth households suffer from adverse labor income effects
- High-wealth households *choose* to save more due to rising real rates



▸ Savings

Summary

Empirically motivated by recent inflation surge, monetary policy response and heterogeneous household exposure

Build a small open economy HANK model with energy calibrated to the Euro Area

Main findings

- Energy price shocks are always contractionary independent of policy response
- Active policy response amplifies aggregate outcomes
- “Looking through” can mitigate adverse outcomes
- Low-wealth households are more strongly impacted
- Drivers of consumption response differ across the wealth distribution

Model

Households

Household problem

$$V_t(a,s) = \max_{c_h, c_e, a'} \frac{c^{1-\sigma}}{1-\sigma} - \psi \frac{N_t^{1+\varphi}}{1+\varphi} + \beta \mathbb{E}_t V_{t+1}(a', s')$$

$$\text{s.t.} \quad p_{h,t} c_h + p_{e,t} c_e + a' = (1 + r_t) a + s w_t N_t$$

$$a' \geq \underline{a}$$

Stone-Geary consumption aggregator

$$c = \left[(1-\alpha_h)^{\frac{1}{\eta}} c_h^{\frac{\eta-1}{\eta}} + \alpha_h^{\frac{1}{\eta}} (c_e - \underline{c})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

- α_h consumption share of energy
- $\underline{c}$ subsistence level of energy consumption
- η elasticity of substitution between domestic and energy goods

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Model

Intermediate firms and labor unions

Production function

$$Y_{j,t} = \left[\alpha_f^{\frac{1}{\theta}} E_{j,t}^{\frac{\theta-1}{\theta}} + (1-\alpha_f)^{\frac{1}{\theta}} N_{j,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

- α_f share of energy in production
- θ elasticity of substitution between labor and energy input

Firm FOC

$$p_{h,t} = \mathscr{M} \frac{1}{\alpha_f} p_{e,t} \left(\frac{E_t}{Y_t} \right)^{\frac{1}{\theta}}$$

$$\frac{p_{e,t}}{w_t} = \frac{\alpha_f}{1-\alpha_f} p_{h,t} \left(\frac{N_t}{E_t} \right)^{\frac{1}{\theta}}$$

- $\mathscr{M}$ (constant) price markup

New Keynesian Wage Philips Curve

$$\pi_t^w = \frac{\varepsilon_w}{\chi} \left[\psi N_t^{1+\varphi} - \frac{\varepsilon_w - 1}{\varepsilon_w} C_t^{-\sigma} w_t \right] + \beta \mathbf{E}_t \pi_{t+1}^w$$

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Model

International trade and finance

Foreign demand

$$C^*_{h,t} = \left(\frac{P^*_{h,t}}{P^*_{e,t}} \right)^{-\lambda} C^*$$

Law of one price

$$P_{e,t} = e_t P^*_{e,t}$$

Real exchange rate

$$Q_t = \frac{e_t P^*_t}{P_t}$$

Goods market clearing

$$Y_t = C_{h,t} + C^*_{h,t}$$

$$C_{h,t} = \int c_{ht}(a,s) d\mu_t(a,s)$$

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Model

Mutual fund and monetary policy

Mutual Fund

$$1 + i_t = (1 + r_{t+1}) \frac{P_{t+1}}{P_t}$$

$$1 + r_t = (1 + i^*) \frac{Q_{t+1}}{Q_t}$$

$$1 + r_{t+1} = \frac{D_{t+1} + j_{t+1}}{j_t}$$

Monetary policy

$$i_t = r_{ss} + \phi_\pi \pi_t^k \qquad k \in \{\text{cpi,h,e}\}$$

- Contrast neutral (constant real rate) and active policy
- React either to contemporaneous or forecast measures of inflation

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Appendix

HANK vs RANK

RANK

- Energy price shock is less severe

HANK

- MPC heterogeneity
- No expenditure switching

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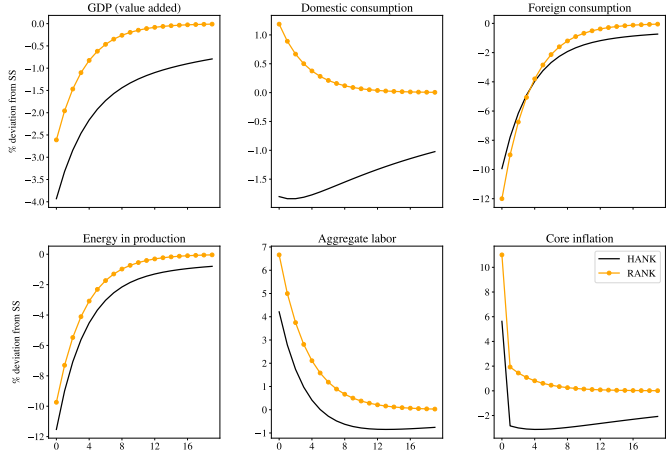

Appendix

Open vs closed economy

Closed economy without profits

- Amplified aggregate and distributional outcomes
- Absence of foreign demand channel

Closed economy with profits

- Energy price shock still contractionary
- Redistribution from high- to low-MPC households

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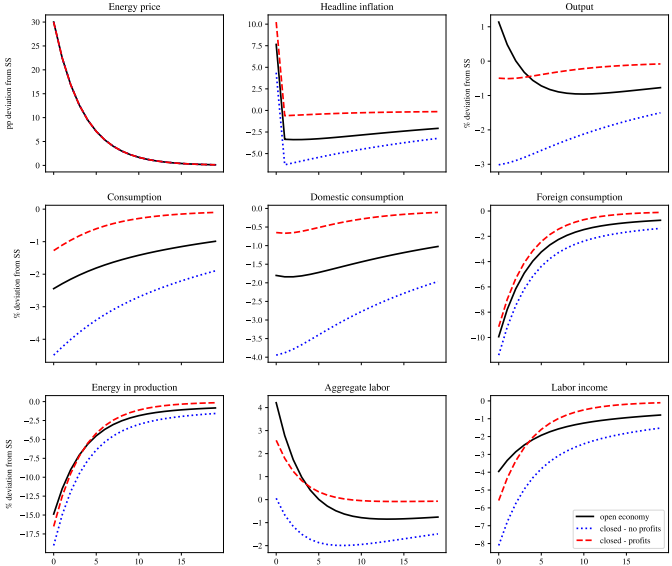


Appendix

Other supply shocks

Less severe real outcomes for other supply shocks

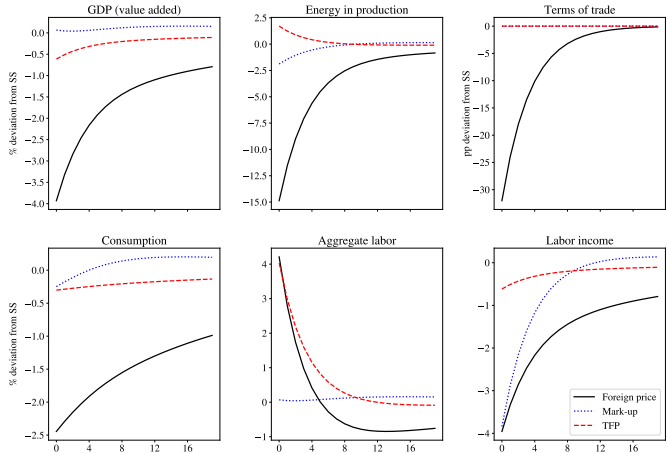
- Same initial increase in price level implies smaller decline in aggregate output and consumption

Productivity shock

- Decrease in labor productivity raises labor demand
- Additional substitution *towards* energy input

Price markup shock

- Amplified aggregate and distributional outcomes
- Absence of foreign demand channel



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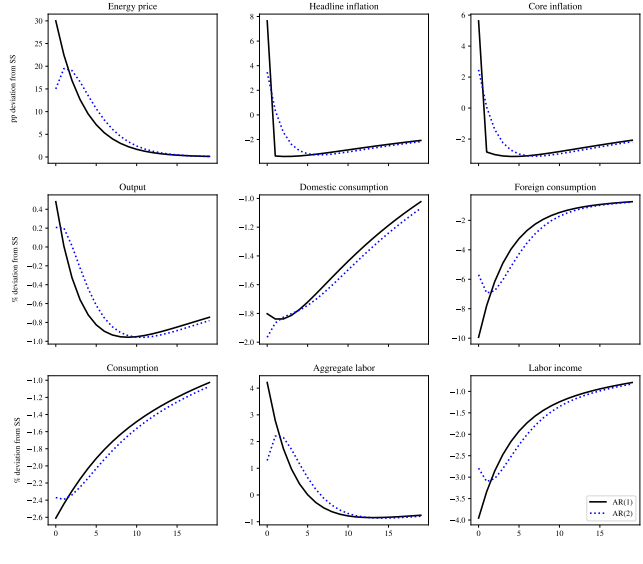
Appendix

Hump-shaped energy shock



Appendix

Hump-shaped energy shock

AR(1) shock (roughly) comparable to AR(2) shock

Headline contemporaneous vs forecast rule

- Stronger real rate increase under forecast rule
- Amplified initial responses

Forecast vs neutral rule

- Neutral rule implies strongly mitigated initial response
- Forecast rule speeds up recovery

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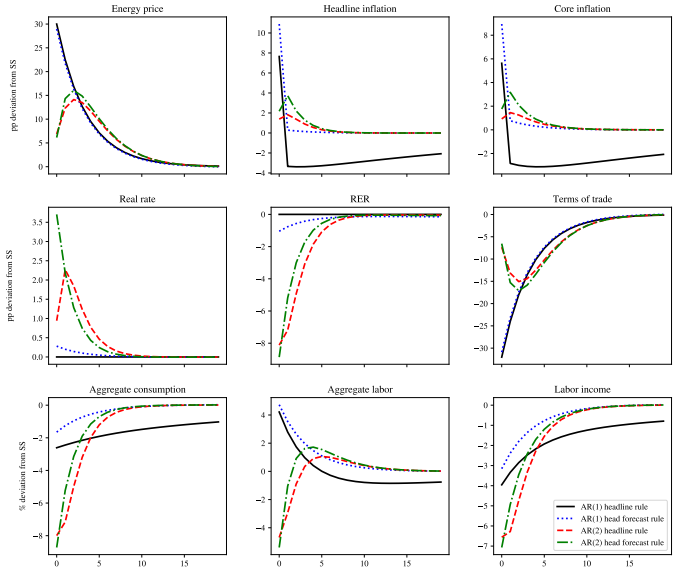
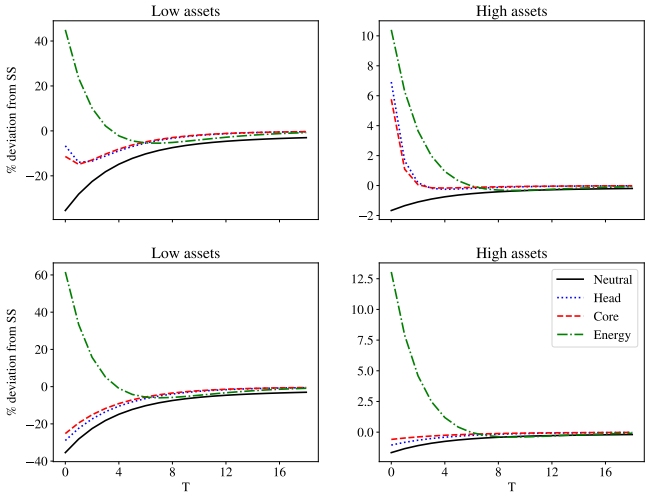


Appendix

Savings response across wealth quintiles



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