Uncertainty and the Business Cycle when Inflation is High

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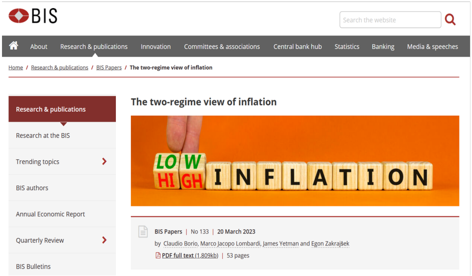
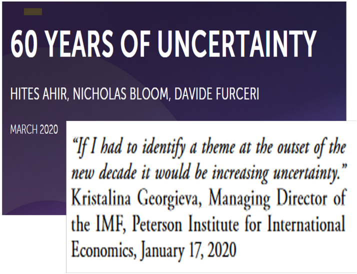
Uncertainty & high inflation

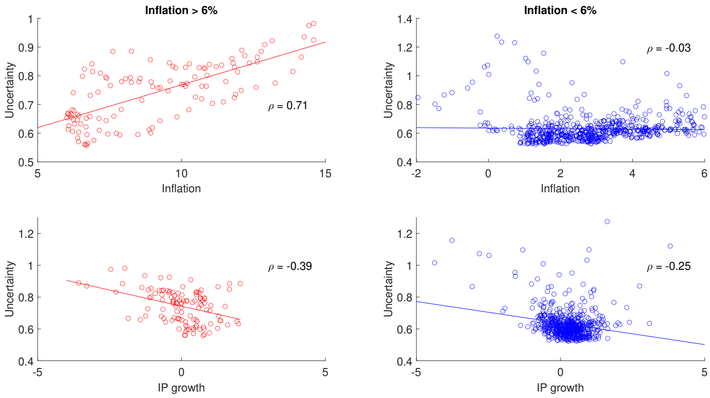




1970s and pandemic: high inflation/uncertainty environment

- Inflation: Reis (2021, 2022), Coibion, Gorodnichenko, Weber (2023), Bernanke and Blanchard (2023)
- Uncertainty: FV-GQ (2020), Altig et al. (2022), Meyer et al. (2022), Cascaldi-Garcia et al. (2022)

Uncertainty & high inflation



- 6% threshold as in Schorfheide (2005), Coibion and Gorodnichenko (2012), our VAR (later)
- LMN's macro uncertainty. Infl. $> 6\% = 16\%$ obs. in 1962M1-2022M7. Rob. to dropping COVID-19

What we do/find

This paper: Evidence and some theory on nonlinear effects of uncertainty shocks when inflation is high

- Estimate a nonlinear SVM VAR à la Alessandri and Mumtaz (2019), find substantially larger BC effects of uncertainty shocks when inflation is high
- Interpret empirical facts with nonlin. NK model with Trend Inflation (TI) + 2nd mom. shocks

Crucial: Upward pricing bias + TI $\Rightarrow$ large effects to an unc. shock!

- Implications:
  - need nonlinear inflation models with TI-related breaks
  - room for state-dependent policies (policy exercise)

Plan of the presentation

- Literature Review
- VAR
- New-Keynesian DSGE model
- Policy Exercise
- Conclusions

Literature review

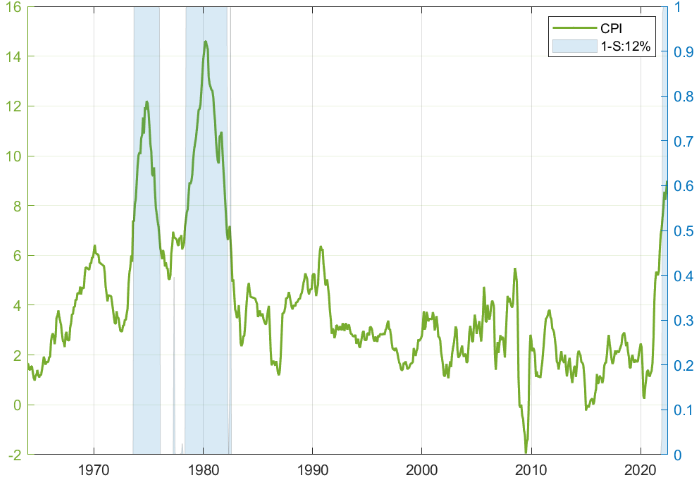
- Nonlinear effects of uncertainty shocks: Alessandri and Mumtaz (2019), Caggiano et al. (2014, 2017, 2022), Cacciatore and Ravenna (2022), Pellegrino et al. (2023), Andreasen et al. (2023)
  - → "Slice" along the inflation dimension (vs. to boom/bust, fin. frictions, ZLB)
- Macroeconomic uncertainty shocks, in particular as drivers of the business cycle: Fernandez-Villaverde et al. (2011, 2015), CCM (2018), Bloom et al. (2018), Angelini et al. (2019), Forni et al. (2022), Fasani, Mumtaz, Rossi (2022) (vs. LMN 2021)
  - → Add a "data point" on macro shocks as drivers of the business cycle
- Trend inflation modeling: Ascari and Sbordone (2014), ... lit.
  - → Model second-moment shock in a nonlinear NK framework with TI

Nonlinear VAR: Alessandri and Mumtaz (2019)

$$
\begin{aligned}
Y_t &= \left(c_1 + \sum_{j=1}^{P} \beta_{1j} Y_{t-j} + \sum_{j=0}^{J} \gamma_{1j} \ln \lambda_{t-j} + \Omega_{1j}^{1/2} e_t \right) S_t \\
&\quad + \left(c_2 + \sum_{j=1}^{P} \beta_{2j} Y_{t-j} + \sum_{j=0}^{J} \gamma_{2j} \ln \lambda_{t-j} + \Omega_{2j}^{1/2} e_t \right) (1 - S_t) \\
S_t &= \mathbf{1}_{\{\pi_{t-1} > \pi^*\}} \\
\Omega_{1,t} &= A_1^{-1} H_t A_1^{-1\prime} \\
\Omega_{2,t} &= A_2^{-1} H_t A_2^{-1\prime} \\
H_t &= \lambda_t \, diag\left(m_1, m_2, m_3, m_4\right) \\
\ln \lambda_t &= \alpha + F \ln \lambda_{t-1} + \eta_t
\end{aligned}
$$

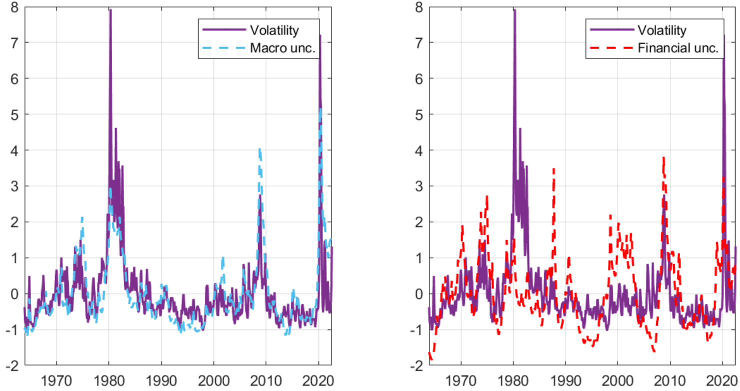
- US Data, Jan. 1962 - July 2022
- Y_t : CPI y-o-y infl., IP Growth, 3m TB rate, 10y int. rate
- P=3, J=3 ('cascading shocks', Diercks et al. 2023)

High inflation regime: Extreme events



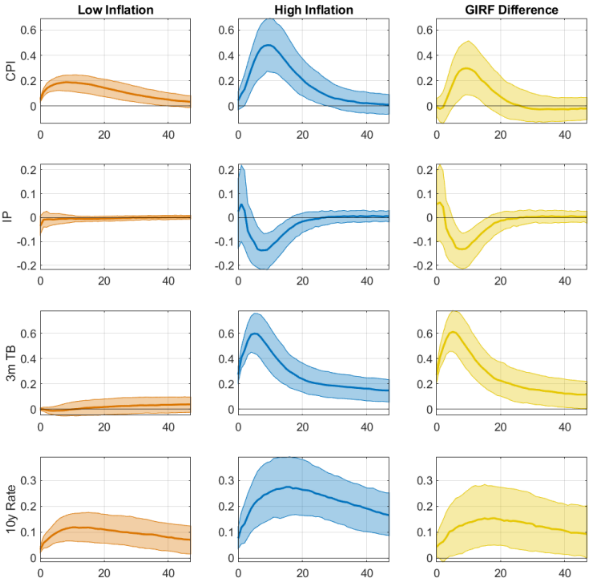
12% of obs. in the high-inflation regime (> 10%, Hansen 1999)

Estimated uncertainty



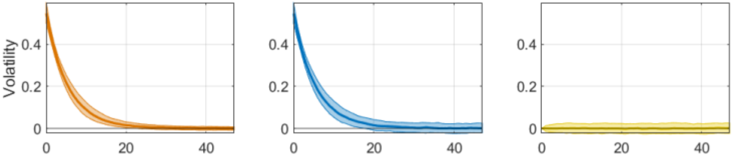
LMN's (2021) measures, correlations: 0.76 (macro), 0.35 (financial)

GIRFs



One standard deviation uncertainty shock. 68% credible bands.

GIRFs (cont'd) and robustness



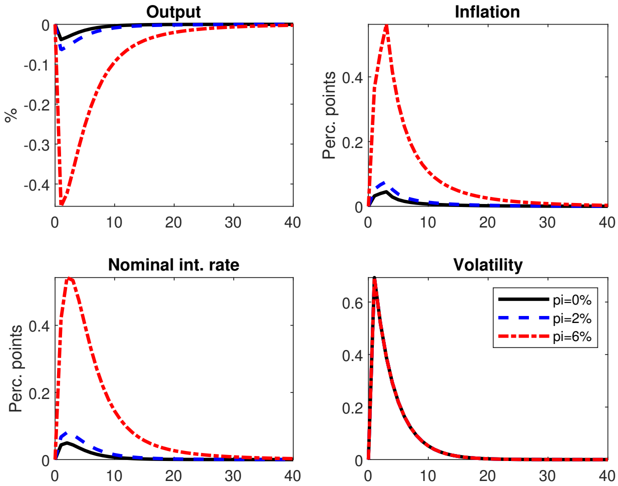
- Volatility IRF equal between regimes $\Rightarrow$ different transmission!
- FEVD (link)
- Uncorrelation with monetary policy / oil supply shocks (link)
- Robust to (link):
  - Model with NFCI (Alessandri and Mumtaz 2019)
  - Model with factor extracted from McCracken and Ng's (2016)
  - Shadow rate as in Wu and Xia (2016)
  - Core CPI
  - No COVID-19 observations
  - TVTI (HP filter, $\lambda = 129,600$ as in Ravn and Uhlig 2002) to date the infl. cycle (link, lit.)

A NK Model with trend inflation and uncertainty shocks

- Standard small-scale New-Keynesian model with trend inflation à la Ascari and Sbordone (2014) + uncertainty shock
- Nonlinear version of the model: richer dynamics with TI
- Features (NK model , calib.):
  - HHs maximize lifetime utility
  - Firms maximize intertemporal profits, Calvo stickiness
  - Trend inflation
  - 2^{nd} moment technology shock as in Fernandez-Villaverde and Guerron-Quintana (2020), Bianchi et al. (2023)
- 3^{rd} order approximation, pruned perturbations (Andreasen, Fernandez-Villaverde, Rubio-Ramirez 2018)

NK model: Role of trend inflation

- IRFs to an uncertainty shock:

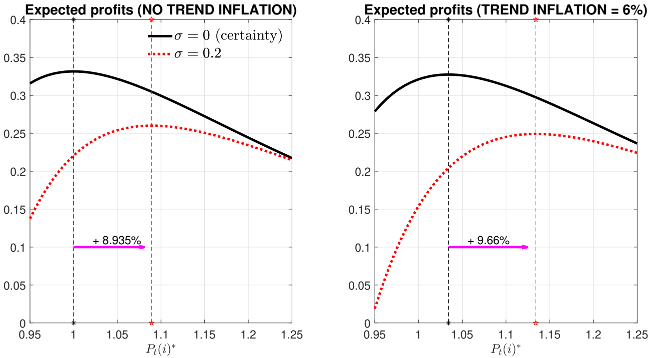


- Price stickiness=f(TI) Medium-scale NK model, alternative shocks
- Intuition?

Two period model: Intuition on the larger effects with TI

- Two-period firm problem, partial equilibrium
- Sticky prices: (CES) Monopolistically-competitive firm sets a price for both periods, $P^*(i)$
  - max intertemporal profits (link)
- Uncertainty: *Firm does not know future aggregate price level*, which can be $P_{t+1} = (1+\pi)P_t \pm \sigma$ with equal probability
  - P_t is known.
  - π: trend inflation
  - σ: uncertainty (mean-preserving)

Two period model: Intuition on the larger effects with TI



if:

- Price rigidities + no uncertainty & no TI ($\pi = 0$) $\Longrightarrow \frac{P^*(i)}{P_t} = 1$
- Price rigidities + uncertainty (when $\pi = 0$) $\Longrightarrow$ **upward pricing bias in $P^*(i)$**
- Price rigidities + uncertainty + **TI** ($\pi > 0$) $\Longrightarrow$ **bigger upward pricing bias in $P^*(i)$**

- General equilibrium?

Scrutinizing the mechanism in GE: Intuition

In response to an **uncertainty shock:**

1. **upward pricing bias** (Fernandez-Villaverde et al 2015, Born & Pfeifer 2021), **recessionary/inflationary effects**
2. $TI > 0$ (Ascari and Sbordone 2014), P upward trending, **firms more forward-looking** to keep relative prices in check

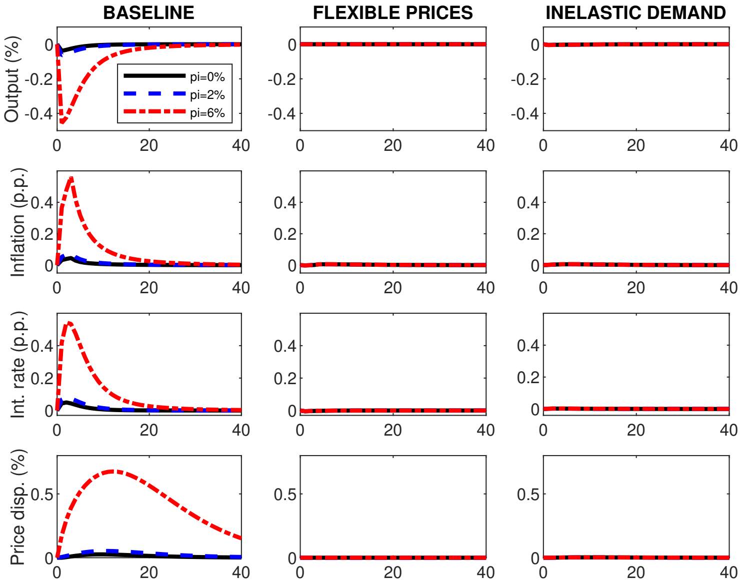
   $\Rightarrow$ **firms set even higher prices, i.e., stronger upward pricing bias** leading to **higher inflation**

$\Longrightarrow$ **higher price dispersion (in presence of TI)** $\Rightarrow$ **deeper recession** (IRFs)

Note: **price dispersion acts as a negative tech shock** (Ascari and Sbordone 2014)

- survey data analysis (Ropele, Coibion, Gorodnichenko 2023)
- micro data (Sheremirov 2020) (vs. Nakamura and Steinsson 2018)
- VAR validation

Scrutinizing the mechanism in general equilibrium



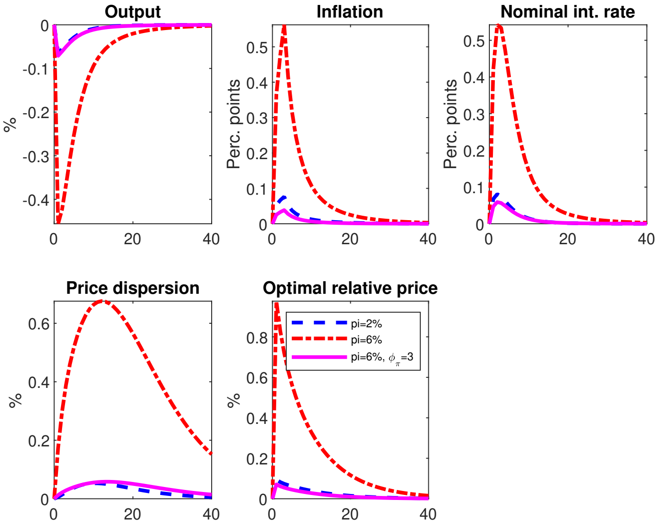
Policy Exercise: Policy needed to mimic TI=2%

The effects of "hawkish" monetary policy when TI is high

Baseline : $\phi_\pi = 1.75$

Counterfactual : $\phi_\pi = 3$

Cost-push shock



Conclusions

- Nonlinear VAR: Uncertainty shocks more powerful when inflation is high
- New-Keynesian model with TI + 2^{nd} moment shocks $\Rightarrow$ breaks in the transmission mechanism similar to those in the data
  - Upward price bias + TI $\Rightarrow$ (big!) price dispersion
- IRFs: 'Hawkish' policy when TI=6% = more 'dovish' policy when TI=2%
- Model/Policy implications:
  - allow for TI-related nonlinearities to understand inflation
  - state-dependent policies

Thank you very much!

EXTRA MATERIAL

FEVD

Variable	Low Inflation		High Inflation	
	One Year	Two Year	One Year	Two Year
CPI	18.0	20.5	28.8	33.1
	(4.6,34.4)	(3.6,42.7)	(2.5,54.6)	(4.0,60.5)
Industrial Production	1.3	1.6	11.8	13.3
	(0.3,5.4)	(0.5,5.7)	(3.5,26.8)	(4.5,29.1)
3-month Treasury Bill	0.9	1.4	61.4	61.7
	(0.1,5.5)	(0.1,9.1)	(30.9,81.3)	(27.3,82.1)
10-year Rate	11.2	14.0	26.3	36.7
	(1.2,26.3)	(1.1,33.5)	(3.2,52.8)	(7.6,65.4)

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Correlation with other shocks

Shock	Source	Sample	Correlation (p-value)
OIL SUPPLY	Baumeister and Hamilton (2019)	1978m1–2019m12	0.014 (0.74)
	Caldara, Cavallo, and Iacoviello (2019)	1987m1-2015m04	-0.09 (0.31)
	Guentner and Henssler (2021)	1973m1–2020m11	0.001 (0.98)
	Kaenzig (2021)	1975m1–2021m12	0.06 (0.16)
MONETARY	Romer and Romer (2004) updated	1969m3–2008m12	0.04 (0.37)
	Jarociński and Karadi (2020)	1990m2–2016m12	-0.01 (0.87)

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Literature review on TI

High inflation $\Rightarrow$ high trend inflation (TI)

- Stock and Watson (2007), Cogley and Sbordone (2008), Cogley, Primiceri, Sargent (2010)

High TI $\Rightarrow$ breaks in the transmission mech. of 1st mom. shocks

- Ascari and Sbordone (2014); Ascari (2004), Ascari and Ropele (2007, 2009), Coibion and Gorodnichenko (2011), Coibion, Gorodnichenko, Wieland (2012), Andreasen et al. (2018), Hirose, Kurozumi, and Van Zandweghe (2019), Ascari, Bonomolo, Haque (2022)

lit. back

Fed's implicit/perceived inflation target: Mumtaz and Theodoridis (2023)

MUMTAZ AND THEODORIDIS

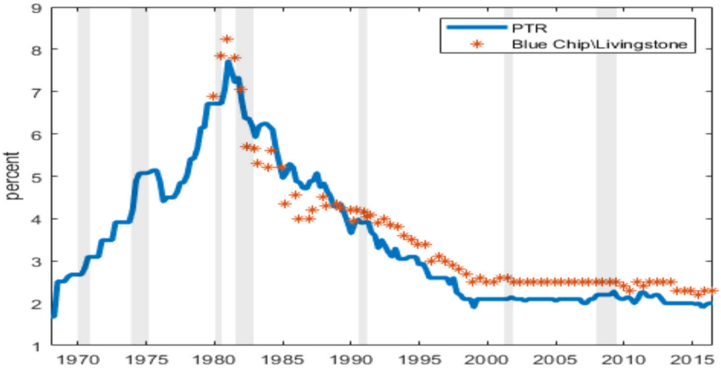

FIGURE 1

MEASURES OF 10-YEAR INFLATION EXPECTATIONS

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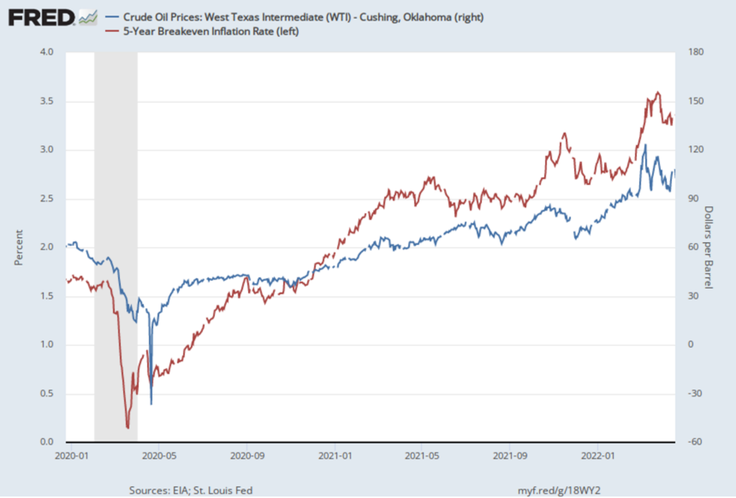
Does the market believe the change in oil prices is permanent? (Fred blog)



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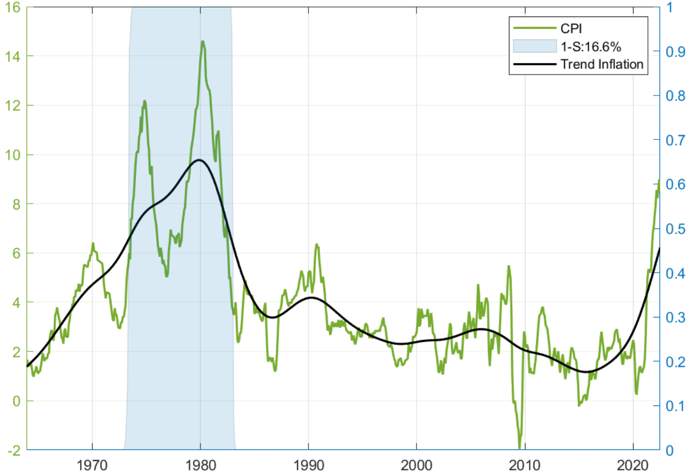
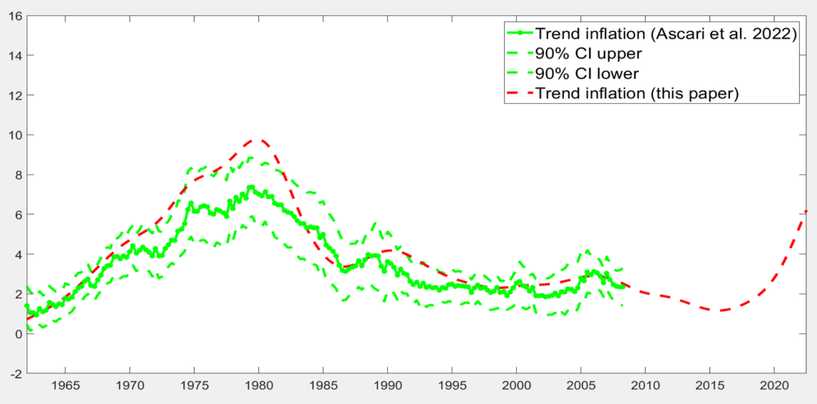
Trend Inflation Regimes



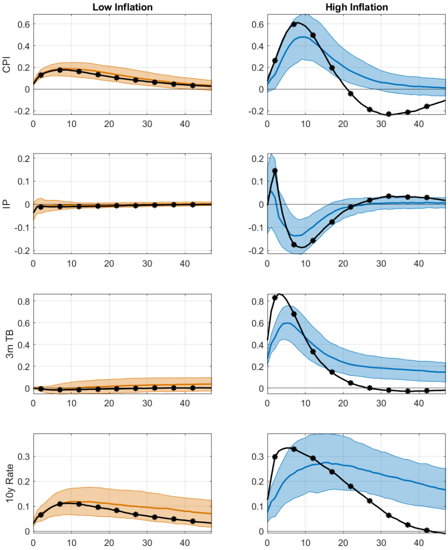
Regimes

Trend inflation, proxies



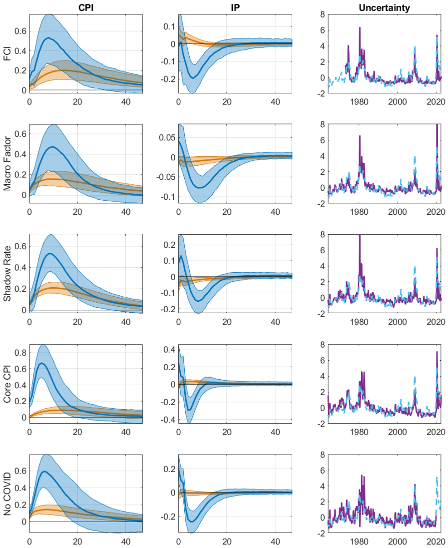
Regimes

VAR with time-varying trend inflation



GIRF

Robustness checks



GIRF

Households

Representative households maximize utility subject to their budget constraint:

$$\max_{C,N,B} E_t \sum_{j=0}^{\infty} \beta^j \left(\frac{C_{t+j}^{1-\sigma}}{1-\sigma} - d_n e^{\zeta_t} \frac{N_{t+j}^{1+\varphi}}{1+\varphi} \right)$$

$$\text{s.t.} \quad \mathrm{P}_t C_t + \tfrac{B_t}{1+i_t} = W_t N_t + D_t + B_{t-1}$$

FOC:

Euler equation: $$\frac{1}{C_t^{\sigma}} = \beta E_t \left(\frac{1}{C_{t+1}^{\sigma}} \frac{P_t}{P_{t+1}} (1+i_t) \right)$$

Labor supply equation: $$\frac{W_t}{P_t} = d_n e^{\zeta_t} N_t^{\varphi} C_t^{\sigma}$$

Firms

CES final good producer:

$$Y_t = \left(\int_0^1 Y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

$$P_t = \left(\int_0^1 P_{i,t}^{1-\varepsilon} \, di \right)^{\frac{1}{1-\varepsilon}}$$

Intermediate goods producers:

$$Y_{i,t} = A_t N_{i,t}$$

$$MC_{i,t} = MC_t = \frac{W_t}{A_t P_t}$$

NK model

Firms

Intermediate goods producers subject to Calvo pricing. $1-\theta$ share of firms allowed to reset prices. Firms set prices to maximize:

$$E_t \sum_{j=0}^{\infty} \theta^j \mathcal{M}_{t,t+j} \left(\frac{P^*_{i,t}}{P_{t+j}} Y_{i,t+j} - TC_{t+j} \right)$$

FOC:

$$\frac{P^*_{i,t}}{P_t} = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{j=0}^{\infty} \theta^j \mathcal{M}_{t,t+j} Y_{t+j} \Pi^{\varepsilon}_{t,t+j} MC_{t+j}}{E_t \sum_{j=0}^{\infty} \theta^j \mathcal{M}_{t,t+j} Y_{t+j} \Pi^{\varepsilon-1}_{t,t+j}},$$

where:

$$\Pi_{t,t+j} \equiv \frac{P_{t+1}}{P_t} \times \cdots \times \frac{P_{t+j}}{P_{t+j-1}}$$

The Role of Price Dispersion

Aggregate labor demand and demand of intermediate goods yield:

$$N_t = \int_0^1 N_{i,t} \, di = \int_0^1 \frac{Y_{i,t}}{A_t} \, di = \frac{Y_t}{A_t} \int_0^1 \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} \, di$$

Resource cost of price dispersion:

$$Y_t = \frac{A_t}{s_t} N_t \qquad \text{where} \qquad s_t \equiv \int_0^1 \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} \, di \geq 1$$

NK model

Monetary Policy and TFP process

Taylor Rule:

$$\frac{1+i_t}{1+\bar{i}} = \left(\frac{1+i_{t-1}}{1+\bar{i}}\right)^{\rho_i} \left(\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_Y}\right)^{1-\rho_i} e^{\nu_t}$$

TFP process:

$$A_t = \rho_A A_{t-1} + e^{\sigma_{t-1}} u_{A,t} \quad (1)$$
$$\sigma_t = (1-\rho_\sigma)\sigma_{ss} + \rho_\sigma \sigma_{t-1} + \sigma_\sigma u_{\sigma,t}, \quad (2)$$

NK model

Calibration

Par.	Description	Value	Source
β	Discount factor	0.99	Ascari and Sbordone (2004)
φ	Frisch elasticity	0	Ascari and Sbordone (2004)
θ	Calvo parameter	0.75	Ascari and Sbordone (2004)
σ	Risk aversion	1	Ascari and Sbordone (2004)
ε	Elasticity of substitution	10	Ascari and Sbordone (2004)
$\bar{\pi}$	Gross quarterly steady state inflation	$(1 + trend\_inflation/100)^{1/4}$	Ascari and Sbordone (2004)
ϕ_{π}	Taylor rule: inflation coefficient	1.75	This paper
ϕ_{Y}	Taylor rule: output coefficient	0.125	Ascari and Sbordone (2004)
ρ_{i}	Taylor rule: int. rate smoothing parameter	0.65	This paper
d_{n}	Labor disutility parameter	Cal. to fix labor to 1/3 in s.s.	Ascari and Sbordone (2004)
ρ_{A}	TFP proc.: persist. of the 1^{st}-moment shock	0.95	Ascari and Sbordone (2004)
σ_{ss}	TFP proc.: steady steady volatility	$ln(0.01)$	This paper
ρ_{σ}	TFP proc.: persist. of the 2^{nd}-moment shock	0.75	This paper
σ_{σ}	TFP proc.: std. of the 2^{nd}-moment shock	0.693	This paper

NK model

IRFs with price stickiness=f(TI)

Calvo parameter as in L'Hullier and Schoenle (2022):

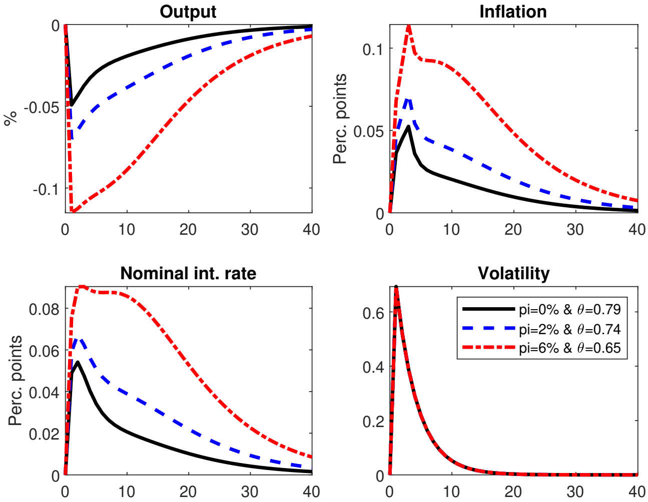
$\bar{\pi} = 0 : \theta = 0.79$

$\bar{\pi} = 2 : \theta = 0.74$

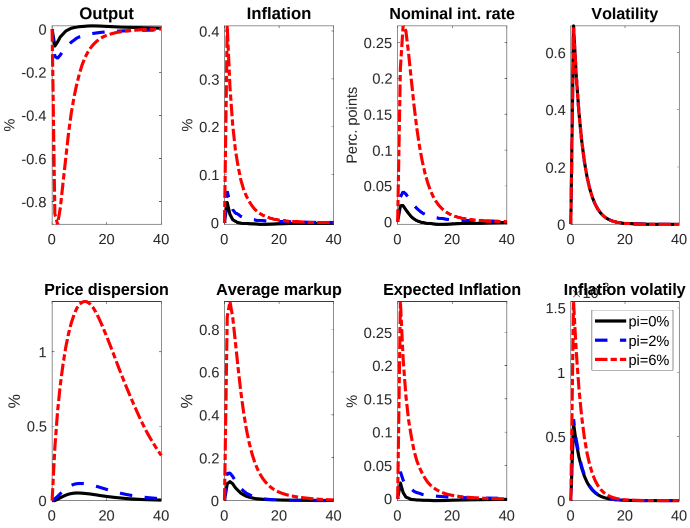
$\bar{\pi} = 6 : \theta = 0.65$

$Frisch = 1$

NK IRF



Full mechanism



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Two-period firm's problem

Firm's problem:

$$\underset{P^*(i)}{Max} \quad \sum_{j=\{0,1\}} \mathbb{E}_t \beta^j \left[\left(\frac{P^*(i)}{P_{t+j}} - \frac{\theta_\mu - 1}{\theta_\mu} \right) \left(\frac{P^*(i)}{P_{t+j}} \right)^{-\theta_\mu} \right].$$

FOC:

$$\Rightarrow P^*(i) = \frac{\theta_\mu}{\theta_\mu - 1} \frac{\mathbb{E}_t \sum_{j=0}^{1} \left(\beta \left(1 + \pi\right)^{\theta_\mu} \right)^j P_t MC(i)}{\mathbb{E}_t \sum_{j=0}^{1} \left(\beta \left(1 + \pi\right)^{\theta_\mu - 1} \right)^j}$$

$\Rightarrow$ In presence of trend inflation firms become more forward-looking

Calibration: $\beta = 0.99$, $\theta_\mu = 6$ (20% markup), $P_t = 1$, $Y = 1$.

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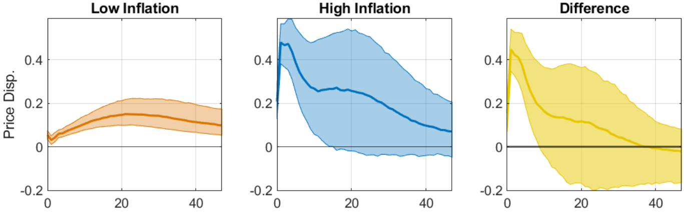
VAR IRFs: Price dispersion

- Aggregate estimate by Ascari et al.(2022), sample 1960Q1 - 2008Q2
  - Nakamura and Steinsson's (2018), Vavra's (2013) samples too short!
- Does price dispersion increase more when inflation is high? YES!



Price dispersion interpolated with Chow-Lin (1971), monthly series: IP growth rates, short/long rates.

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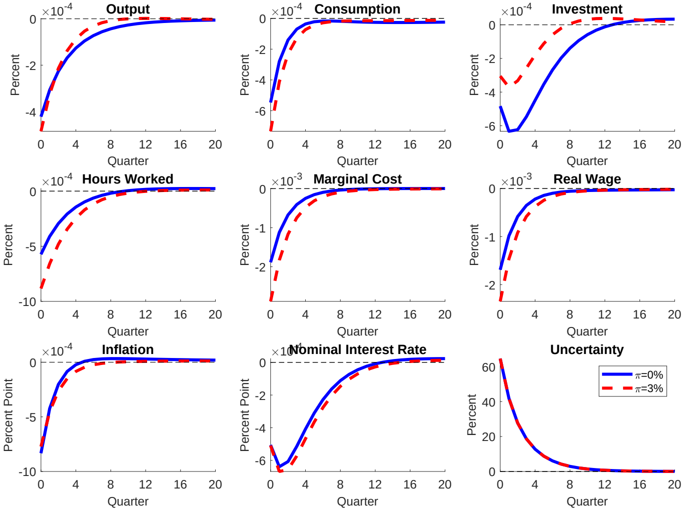
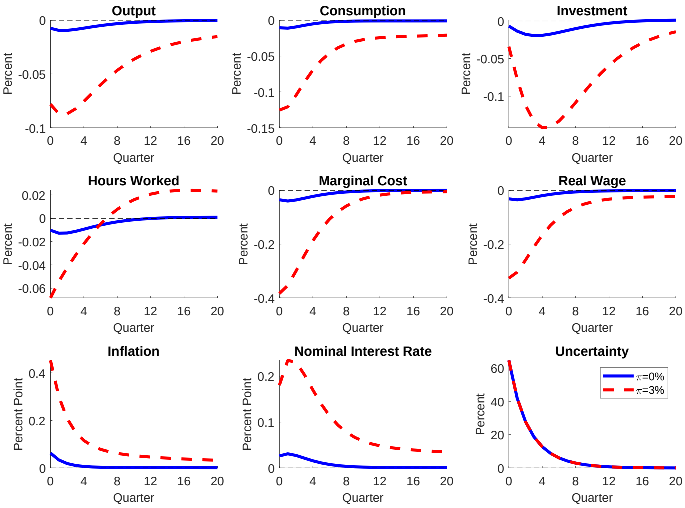
Fiscal policy uncertainty Shock: Oh's (2020) model



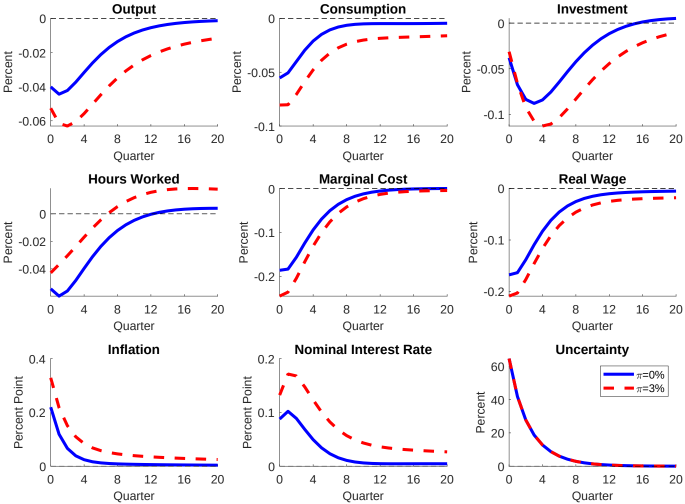
NK IRF

Markup uncertainty shock: Oh's (2020) model



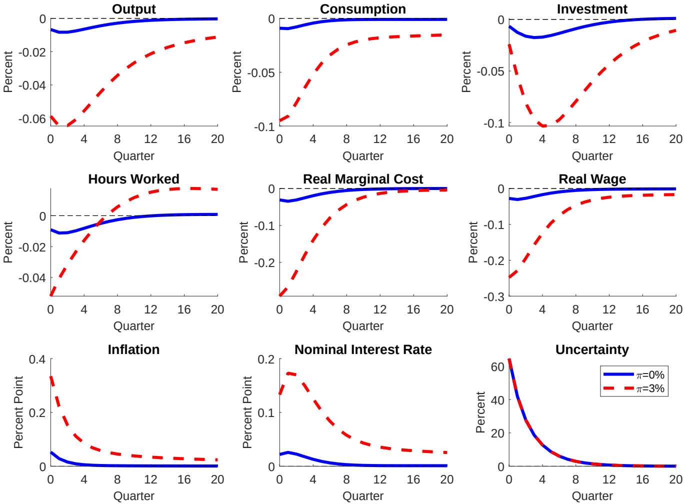
NK IRF

Monetary policy uncertainty shock: Oh's (2020) model



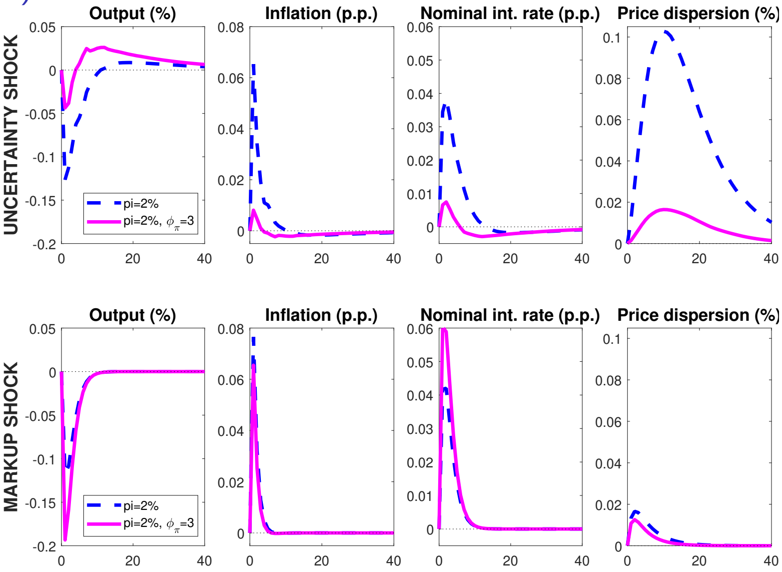
NK IRF

Preference uncertainty shock: Oh's (2020) model



NK IRF

Cost-Push and Uncertainty Shock in Ascari and Sbordone (2014)



Policy