Monetary Policy, Markup Dispersion, and Aggregate TFP

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Motivation

What is the transmission mechanism of monetary policy?

Rigid prices are central in the workhorse New Keynesian model

Monetary transmission under heterogeneity in price rigidity?

Empirical evidence: Bils/Klenow (04), Nakamura/Steinsson (08), Gorodnichenko/Weber (16), ...

Model dynamics: Carvalho (06), Nakamura/Steinsson (10), Pasten/Schoenle/Weber (19), ...

Optimal monetary policy: Aoki (01), Eusepi/Hobijn/Tambalotti (11), ...

A novel mechanism

Initial condition

$\hookrightarrow$ firms with more rigid prices set higher markups
(*this can be optimal in the NK model*)

Contractionary monetary policy shock

$\hookrightarrow$ lowers marginal cost

$\hookrightarrow$ increases markup dispersion

$\hookrightarrow$ lower aggregate TFP

Empirical and quantitative findings

Empirical evidence

- Firms with more rigid prices have higher markups
- MP shocks raise markup dispersion across firms
- Aggregate TFP falls by 0.5% two years after 1sd MP shock
  Response of markup dispersion can account for TFP response

New Keynesian model with heterogeneous price rigidity

- Explains half of peak response in markup dispersion

Related literature

Monetary policy and heterogeneous price rigidity

Carvalho (06), Gorodnichenko/Weber (16), Pasten/Schoenle/Weber (18), Clayton/Jaravel/Schaab (18), Baqaee/Farhi (17), ...

- This paper: precautionary price setting

Aggregate productivity response to MP shocks

Evans/Santos (02), Christiano/Eichenbaum/Evans (05), Moran/Queralto (18), Garga/Singh (19), Jorda/Singh/Taylor (19), ...

- This paper: allocative efficicency

Allocative efficiency over the business cycle

Eisfeldt/Rampini (06), Bloom (09), Khan/Thomas (13), Ascari/Sbordone (14), Meier (18), ...

- This paper: evidence on response to business cycle shock

Environment

Price-setting problem (under CES preferences and CRS technology)

$$\max_{\{P_{it+j}\}_{j=0}^{T}} \mathbb{E}_t \sum_{j=0}^{T} \beta^t \left[\left(\frac{P_{it+j}}{P_{t+j}} - W_{t+j} \right) \left(\frac{P_{it+j}}{P_{t+j}} \right)^{-\eta} Y_{t+j} - \text{adjustment cost}_{it+j} \right]$$

$\rightarrow$ profits fall more rapidly for low prices than for high prices:
precautionary motive to set higher markups

Environment

Price-setting problem (under CES preferences and CRS technology)

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$\rightarrow$ profits fall more rapidly for low prices than for high prices: precautionary motive to set higher markups

Aggregate prices and demand (P_t, W_t, Y_t) follow a joint log-normal process that is iid in levels or growth rates

Summary of main theoretical results

Suppose firms face different Calvo or Rotemberg frictions

- Under weak conditions, firms set markups $\mu_{it}^* > \eta/(\eta - 1)$, and markups μ_{it}^* decrease in price adjustment frequency go
- Similar for Rotemberg friction

Summary of main theoretical results

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Markup dispersion increases in marginal costs if firms with higher markups have lower pass-through from marginal costs to price go

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Aggregate TFP decreases in markup dispersion go

(see Hsieh/Klenow 09, Baqaee/Farhi 19)

All details are provided in the paper: see Propositions 1-3.

Testable implications

1. Firms that adjust prices less frequently have higher markups
2. Markup dispersion increases after MP shocks
3. Markups respond more for firms that adjust prices less frequently
4. Aggregate TFP falls after MP shocks

Measuring markups and price rigidity

Markups can be estimated as

$$\mu = \frac{\text{output elasticity of } X}{\text{revenue share of } X}$$

assuming cost minimization with flexible factor X (De Loecker/Warzynski 12)

Measuring markups and price rigidity

Markups can be estimated as

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- Quarterly firm-level Compustat balance sheet data

$$\text{output elasticity}_{it} = \begin{cases} \text{Cost share}_{st} \\ \text{Translog elasticity}_{it} \\ \text{Cobb Douglas elasticity}_{st} \end{cases}$$

$$\text{revenue share}_{it} = \frac{\text{Costs of goods sold}_{it}}{\text{Sales}_{it}}$$

De Loecker/Eeckhout/Unger (19)

Measuring markups and price rigidity

Markups can be estimated as

$$\mu = \frac{\text{output elasticity of } X}{\text{revenue share of } X}$$

- Quarterly firm-level Compustat balance sheet data

Price adjustment frequency constructed from

- Five-digit sector-level averages from PPI micro data
  Pasten/Weber/Schoenle (19)
- Firm-level sales composition across sectors
  using Compustat segment files

① Firms with more rigid prices have higher markups

	log(Markup)		
Price adjustment frequency	-0.499	-0.347	-0.069
	(0.003)	(0.004)	(0.008)
Implied price duration	0.080	0.054	0.015
	(0.001)	(0.001)	(0.001)
Two-digit industry FE	N	Y	N
Four-digit industry FE	N	N	Y

Separate regressions of log markups on price adjustment frequency and implied price duration from 2005 until 2011. Robust standard errors in parentheses. ▸ Translog

Identification of dynamic effects

MP shocks constructed as high-frequency changes in the 3-months ahead federal funds future price around FOMC announcements

Kuttner (01), Gertler/Karadi (15), Gorodnichenko/Weber (16), ... ▸ Series

$$\varepsilon_\tau^{\text{MP}} = \text{f}_{\tau+20 \text{ min.}} - \text{f}_{\tau-10 \text{ min.}}$$

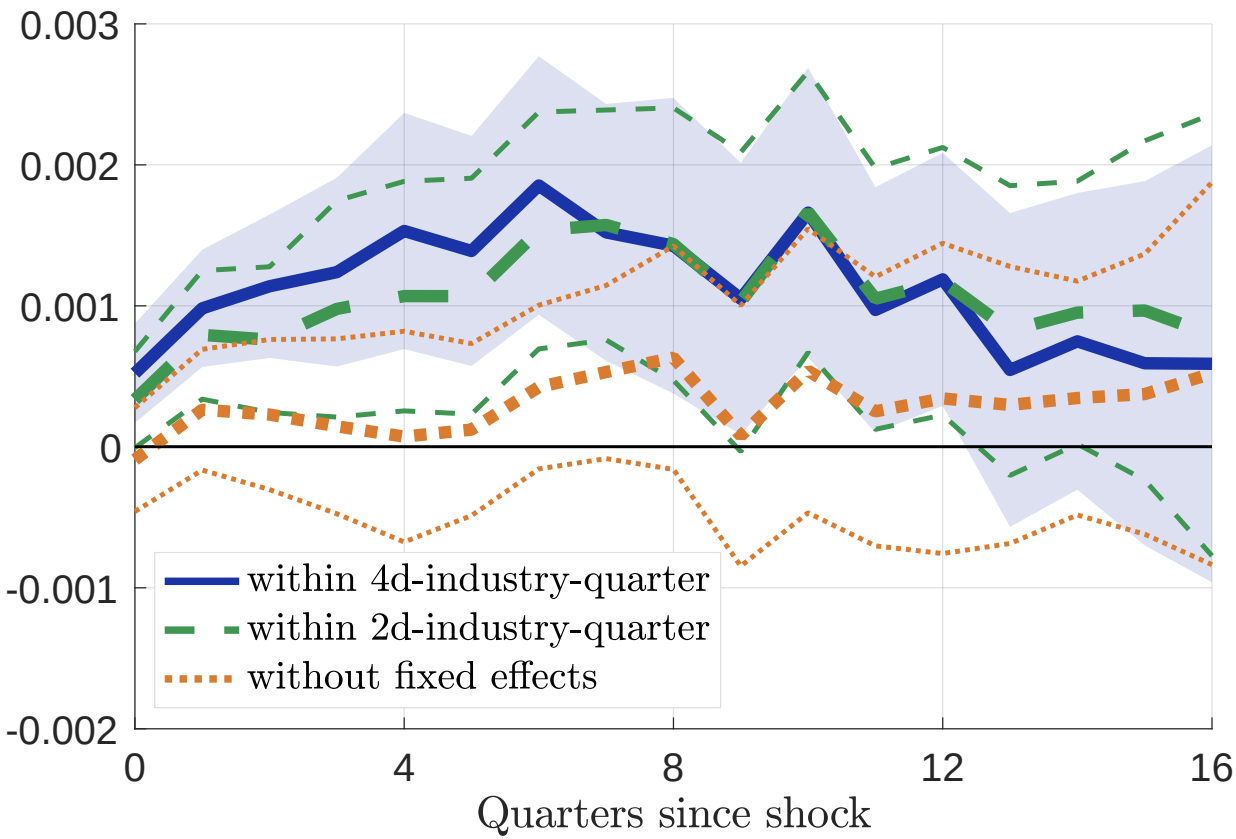
Time series of shocks: 1995Q1–2018Q3

Estimate local projections

$$y_{t+h} - y_{t-1} = \alpha^h + \beta^h \varepsilon_t^{\text{MP}} + \gamma^h Z_{t-1} + u_t^h$$

where β^h are the impulse responses at horizon $h = 0, \ldots, 16$

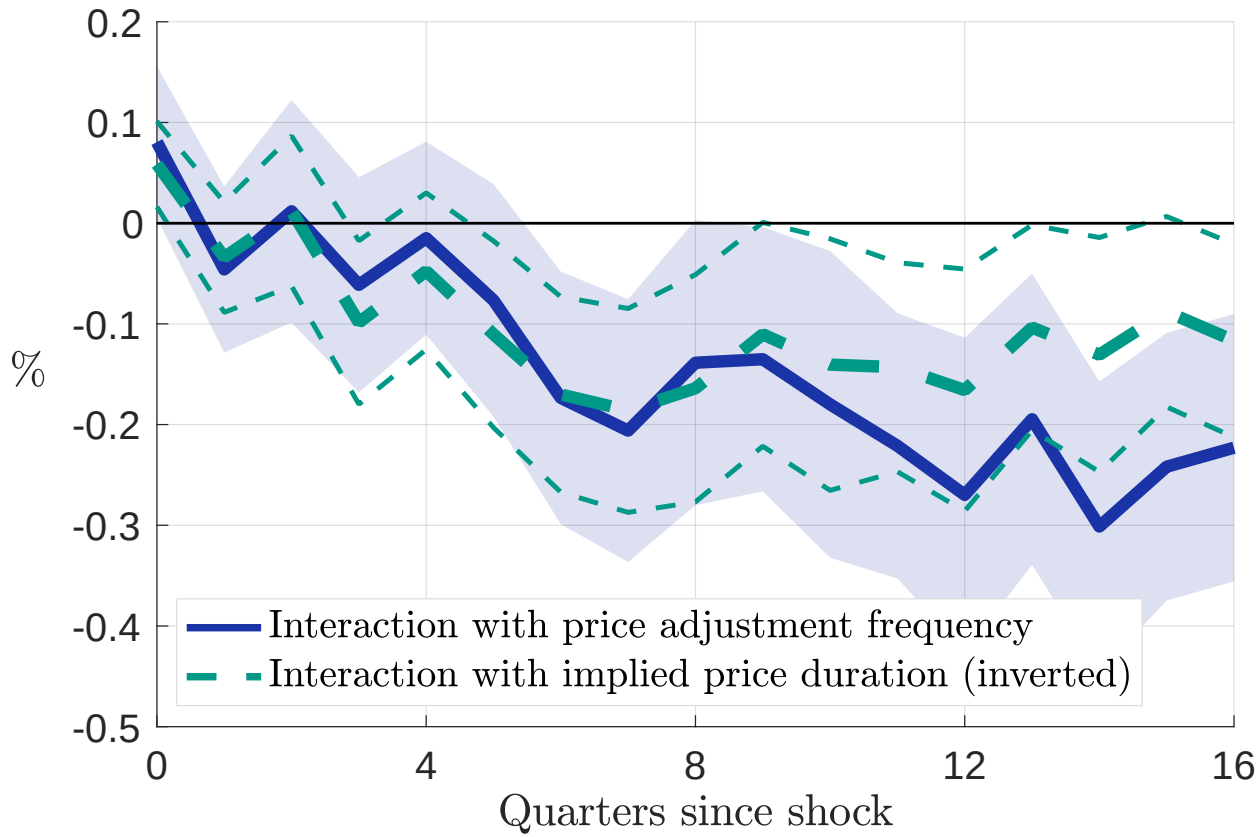
② MP shock raises markup dispersion



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands. ▸ Translog ▸ Series

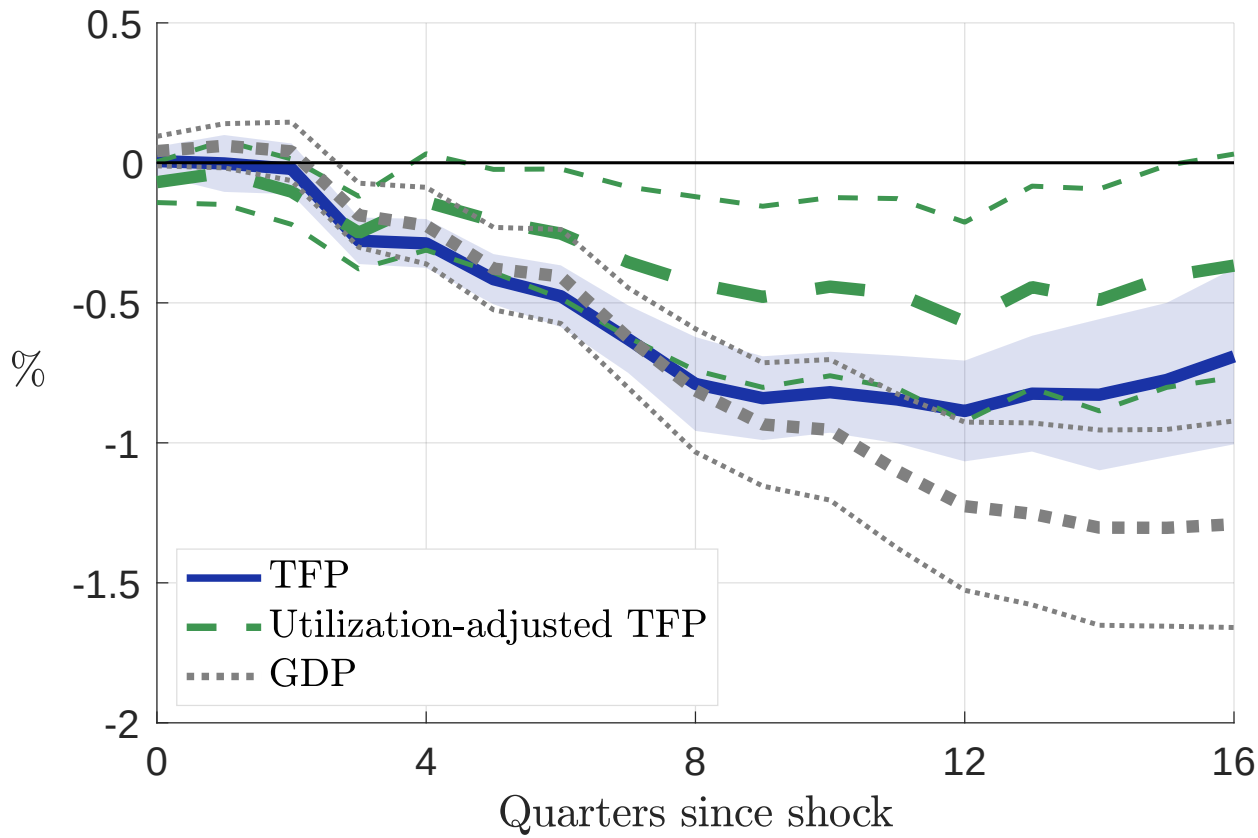
③ Markups of rigid-price firms increase by more

$$y_{it+h} - y_{it-1} = \alpha_t^h + B^h Z_{it-1} \varepsilon_t^{MP} + \Gamma^h Z_{it-1} + u_{it}^h,$$



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands. translog

④ Aggregate TFP falls and GDP falls

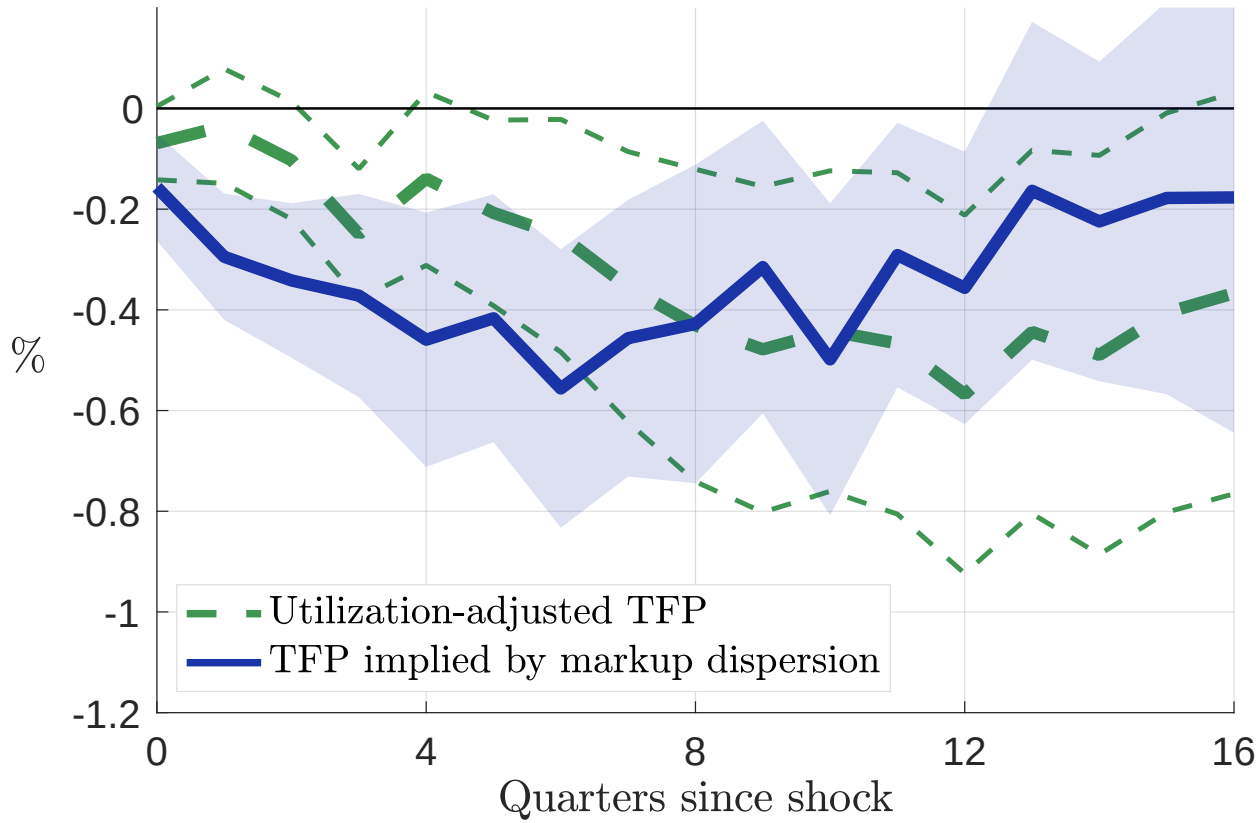


Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

▸ Details ▸ More

Imputed aggregate TFP response

Using $\Delta \text{TFP}_t = -\frac{\eta}{2}\Delta \mathbb{V}_t(\log \mu_{it})$ with $\eta = 6$ closely matches the (utilization-adjusted) TFP response:



Robustness

Monetary policy shocks

- Alternative future prices ▷
- News/information component ▷
- Unconventional MP ▷

Compustat: data treatment, delisting ▷

Alternative explanations for the TFP decline ▸ R&D

New Keynesian model with heterogeneous price rigidity

Model setup

- 1 sector, rep. household, CES preferences, CRS technology
- Taylor rule

$$R_t = R_{t-1}^{\rho_r} \left[\frac{1}{\beta} \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \left(\frac{Y_t}{\tilde{Y}_t} \right)^{\phi_y} \right]^{1-\rho_r} \exp\{\nu_t\}, \quad \nu_t \sim \mathcal{N}(0, \sigma_\nu^2)$$

- Heterogeneous Calvo friction: half of firms adjust always, half of firms adjust with 1/8 quarterly reset probability

New Keynesian model with heterogeneous price rigidity

Model calibration

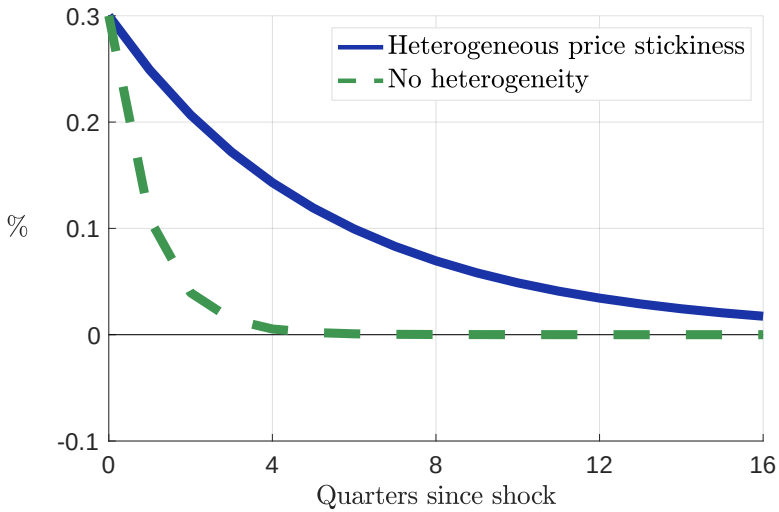
- Target *relative* labor response to MP shock
- Target federal funds rate response to MP shock
- More details ▸ Table

Model solution

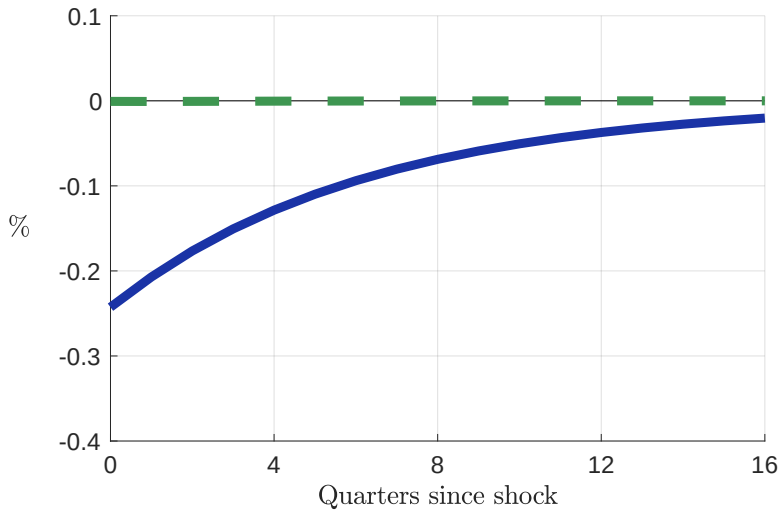
- To capture precautionary price-setting motive, requires (at least) third-order approximation
- Use Meyer-Gohde (15) algorithm

Stochastic steady state: sticky-price firms set 5% higher markup

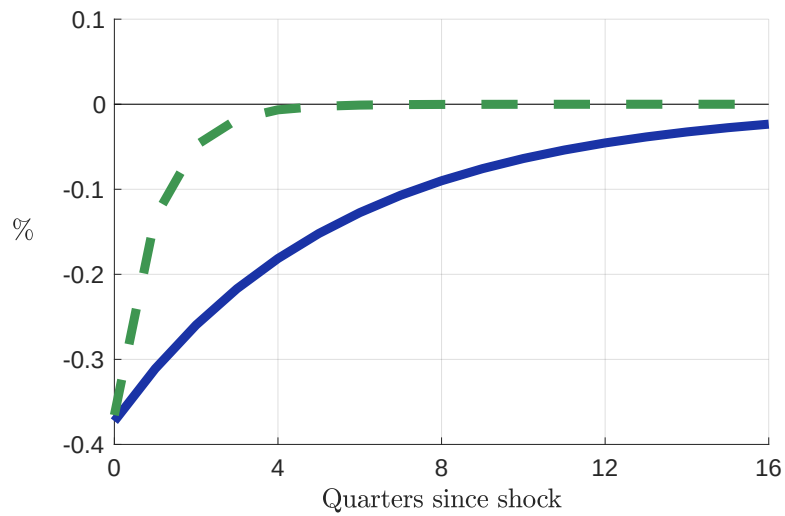
Nominal rate



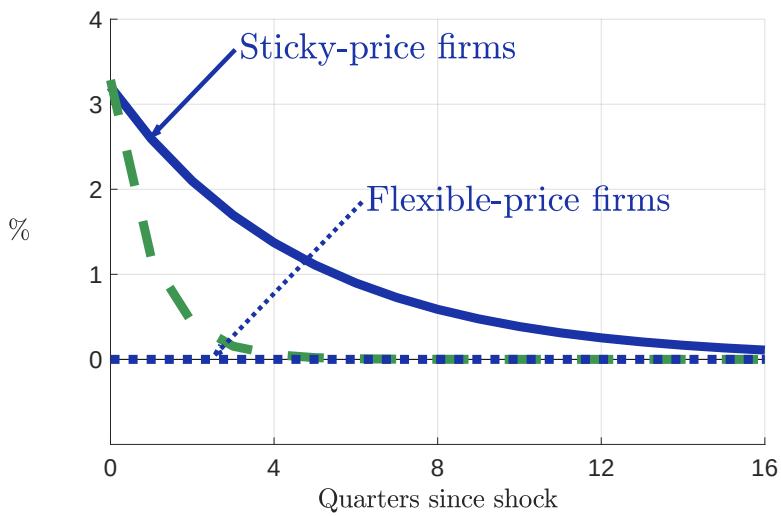
Aggregate TFP



GDP



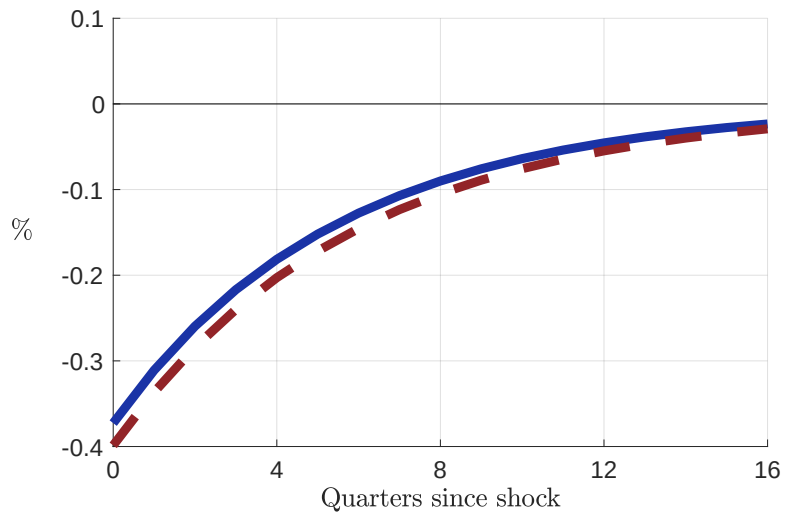
Average markups



What is natural output?

If monetary authority (mis)perceives endogeneous TFP responses as exogeneous productivity shocks, the std. of GDP is 10% higher

GDP response



solid line: baseline natural output; dashed line: misperceived natural output

▸ tfp shock

Why not a standard New Keynesian model?

Standard NK models with homogeneous price rigidity

- Markup dispersion is zero at the steady state
- First-order approximation: unchanged markup dispersion
- Second-order approximation: increased markup dispersion after positive and negative shocks

NK model with trend inflation and homogeneous price rigidity

- Markup dispersion *decreases* after contractionary MP shock

  Ascari/Sbordone (14)

Conclusion

Heterogeneity in price rigidity matters for monetary transmission

$\hookrightarrow$ quantitatively relevant misallocation channel of monetary policy

Our contributions

- characterize novel mechanism
- provide novel empirical evidence in its support
- study quantitative relevance in New Keynesian model

Thank you!

Aggregate productivity

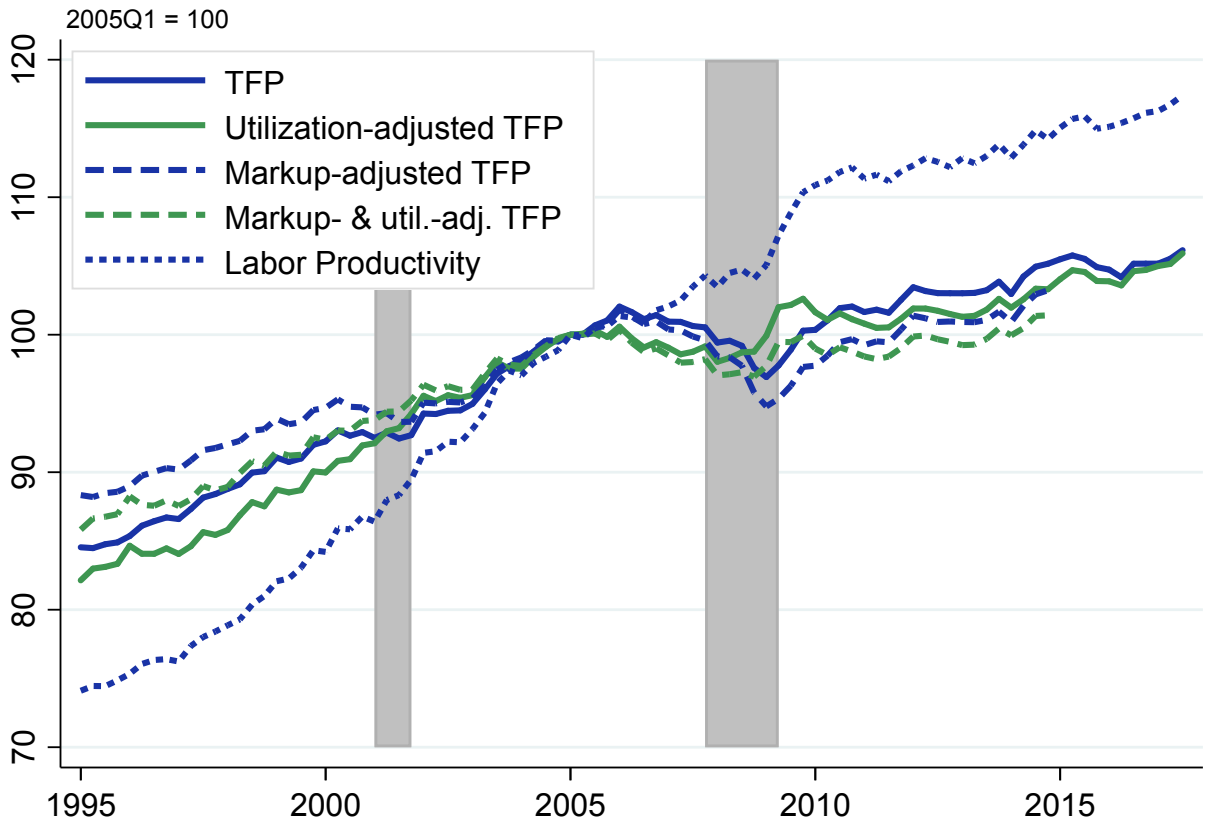
Solow's (57) residual

$$\mathrm{TFP}_t = \log Y_t - w_t \log K_t - (1 - w_t) \log L_t, \qquad w_t = \frac{R_t K_t}{P_t Y_t}$$

- We use Fernald's (14) aggregate TFP
- and utilization-adjusted aggregate TFP: $\mathrm{TFP}_t^{\mathrm{util}} = \mathrm{TFP}_t - u_t$
- and aggregate labor productivity

Back

Measured aggregate productivity



Aggregate productivity at quarterly frequency. TFP and utilization-adjusted TFP are from Fernald (2014), labor productivity is real output per hour in the nonfarm business sector. Markup adjustment is based on Hall (1986) using markup estimates from De Loecker et al. (2018). Shaded gray areas indicate NBER recession dates.

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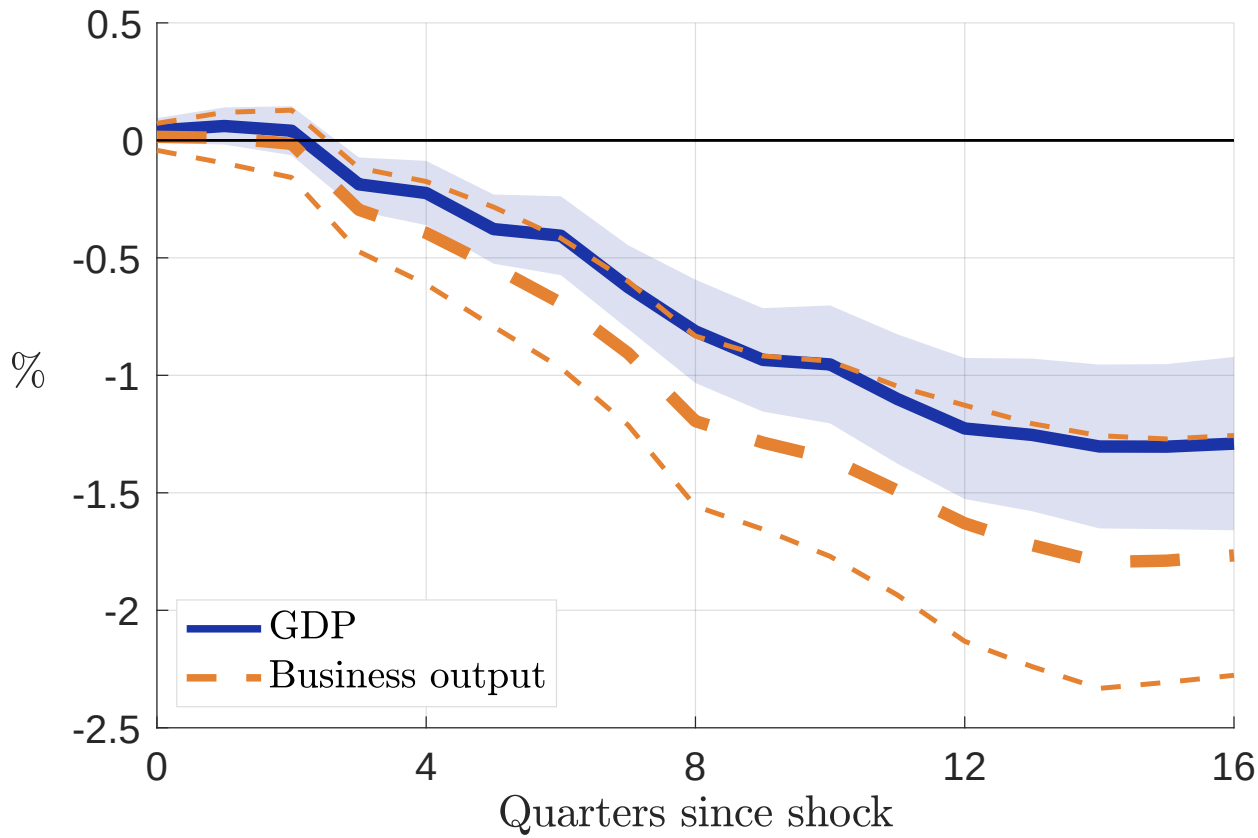
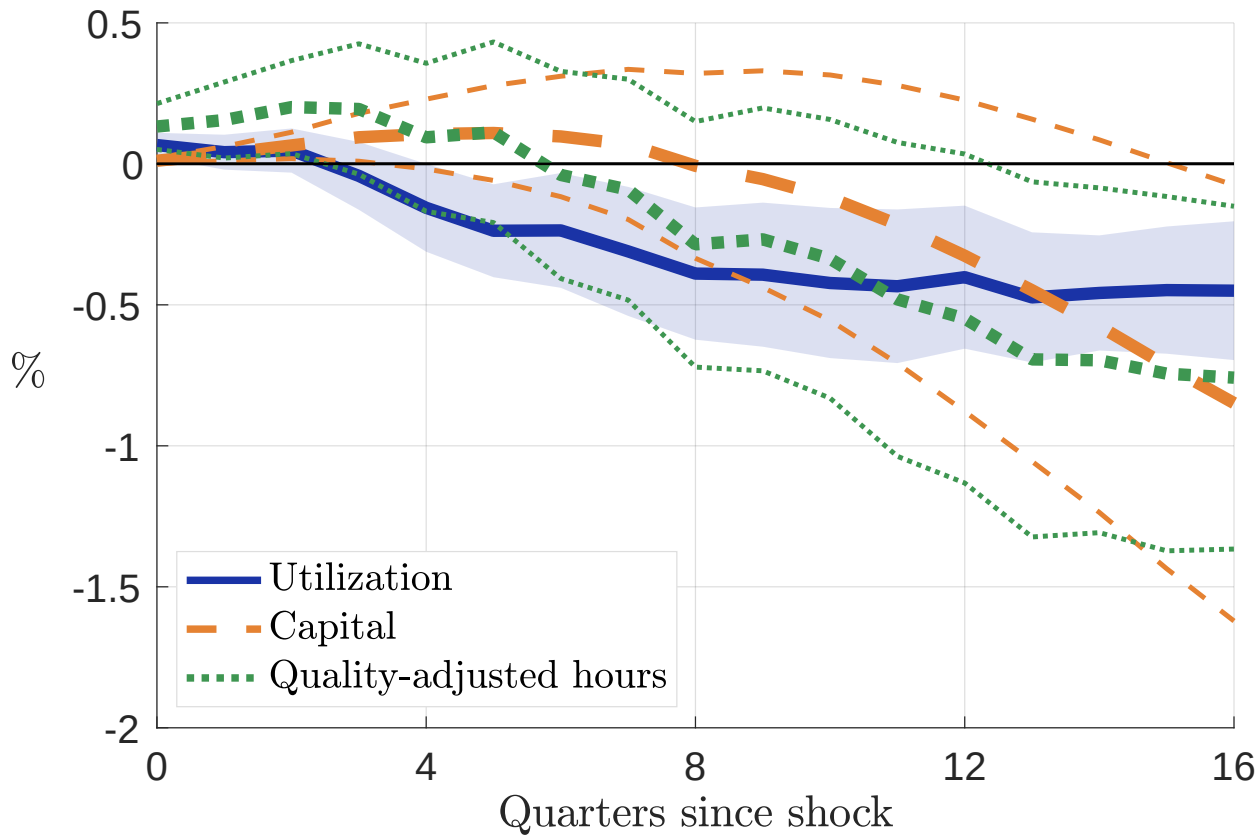
Response of aggregate output



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

Back

Response of aggregate inputs



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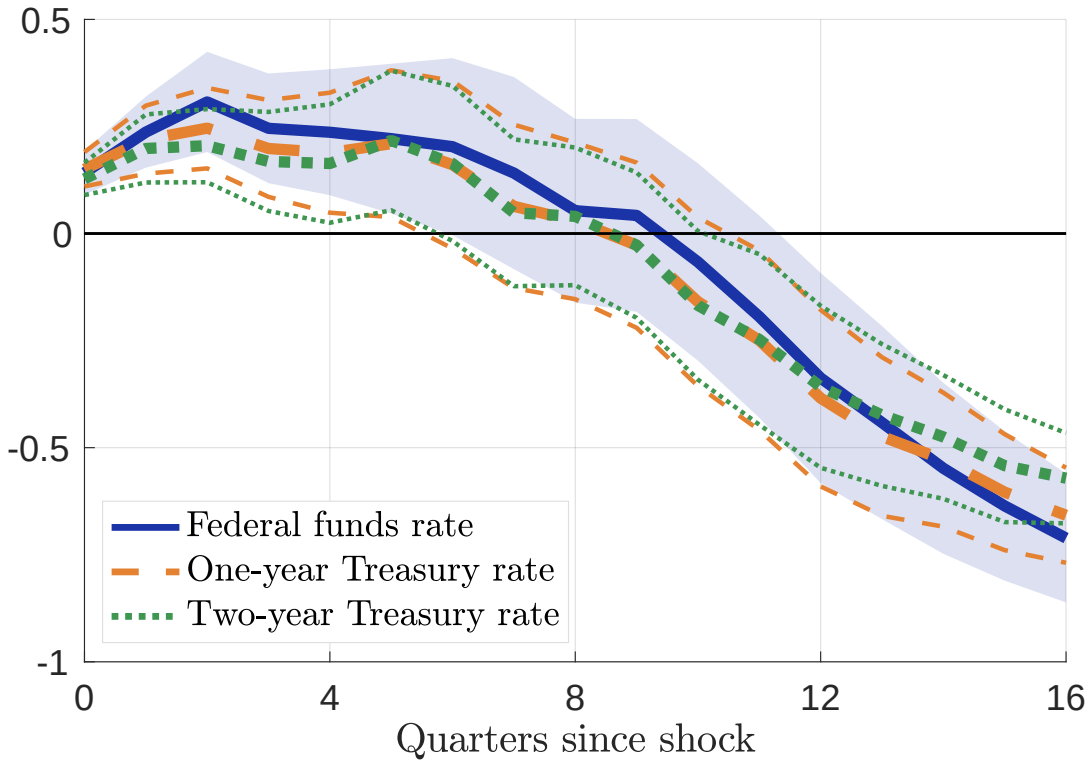
Back

Interest rate response



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

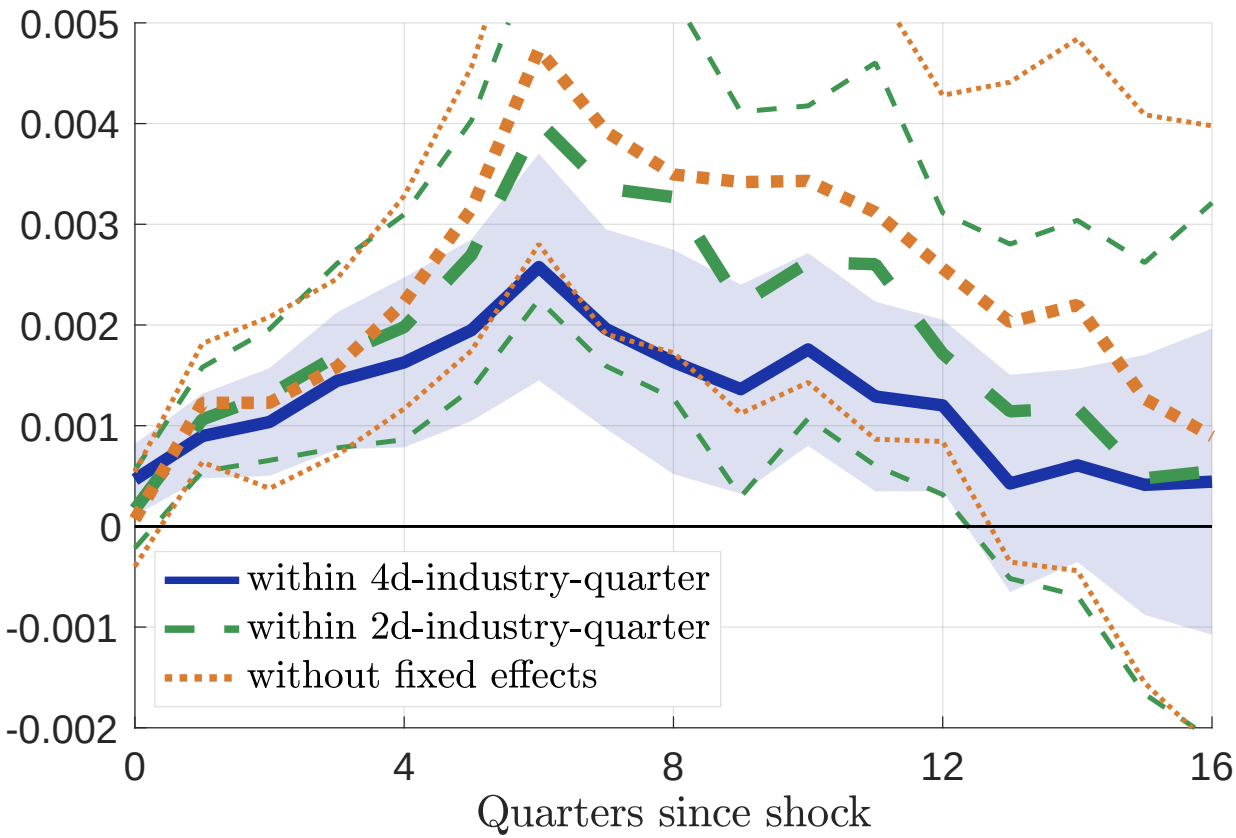
Back

① Firms with more rigid prices have higher markups (translog)

	log(Markup)		
Price adjustment frequency	-1.019	-0.718	-0.103
	(0.012)	(0.015)	(0.022)
Implied price duration	0.144	0.090	0.021
	(0.002)	(0.002)	(0.003)
Two-digit industry FE	N	Y	N
Four-digit industry FE	N	N	Y

Separate regressions of log markups on price adjustment frequency and implied price duration from 2005 until 2011. Robust standard errors in parentheses. back

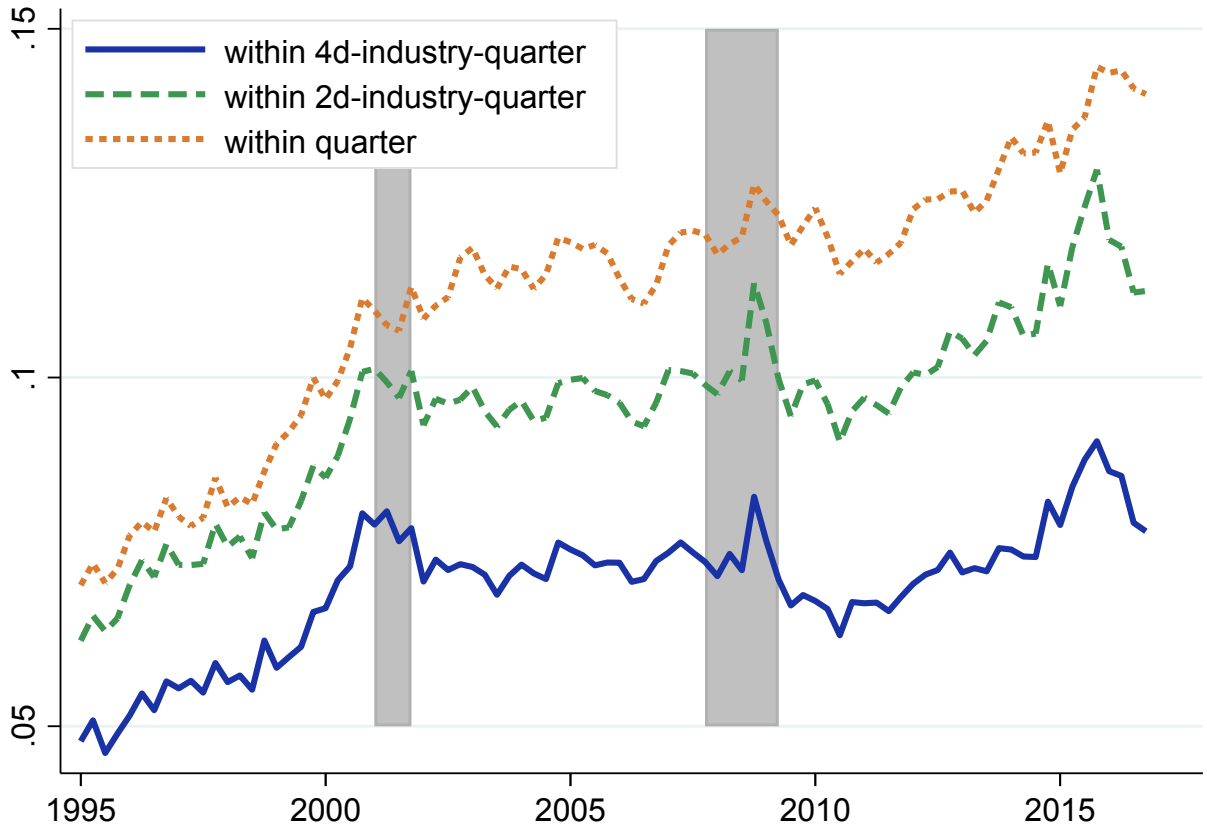
② MP shock raises markup dispersion (translog)



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

back

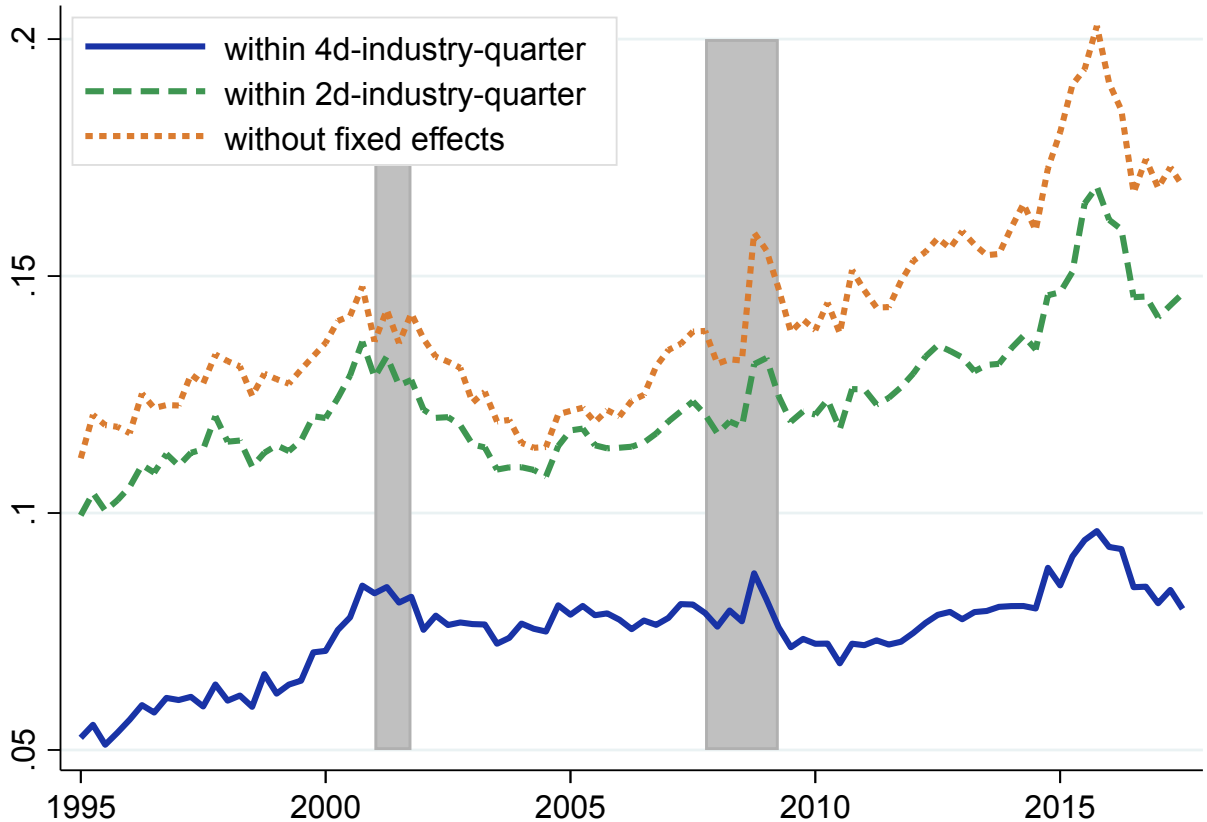
Markup dispersion (cost shares)



Cross-sectional variance of log markup in Compustat data at quarterly frequency. Four- and two-digit industry-quarter fixed effects are removed, respectively. Shaded gray areas indicate NBER recession dates.

back

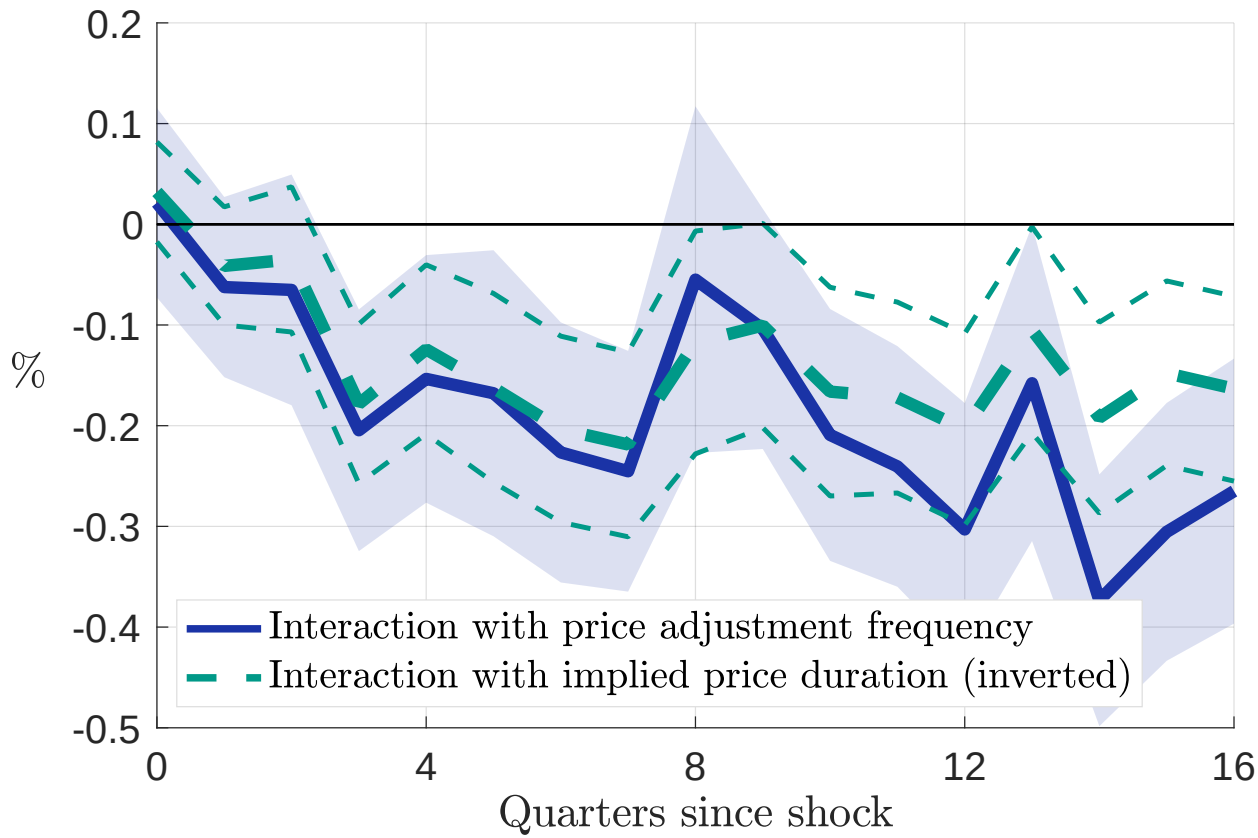
Markup dispersion (translog)



Cross-sectional variance of log markup in Compustat data at quarterly frequency. Four- and two-digit industry-quarter fixed effects are removed, respectively. Shaded gray areas indicate NBER recession dates.

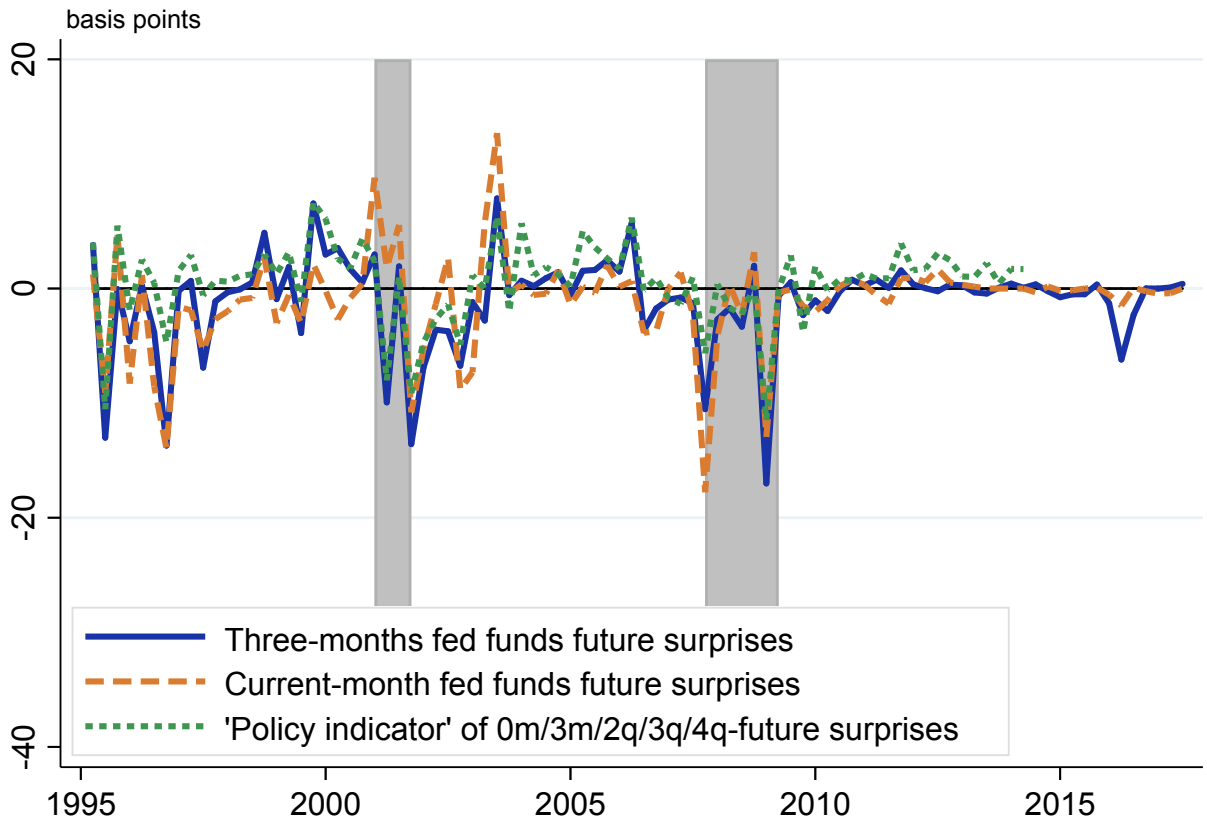
back

③ Markups of rigid-price firms increase by more (translog)



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands. back

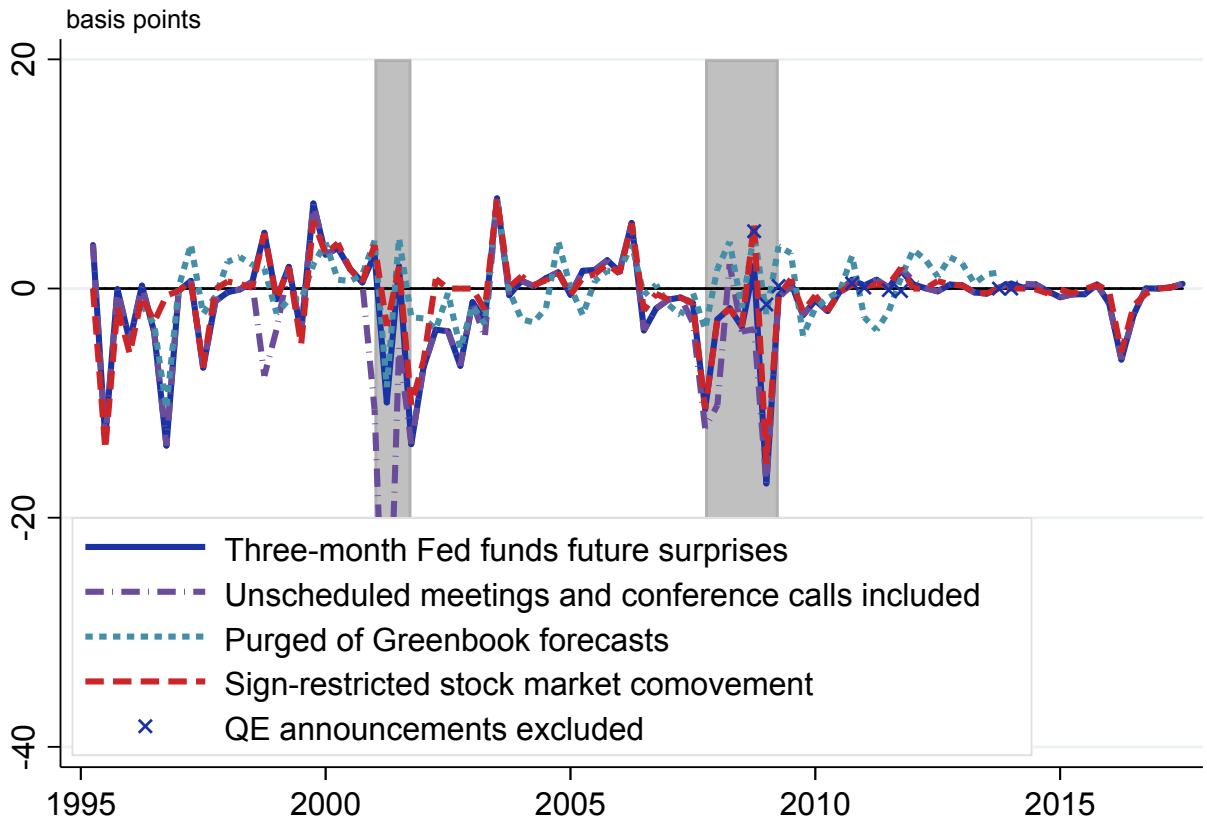
Monetary policy shocks I



Monetary policy shocks at quarterly frequency. Shaded gray areas indicate NBER recession dates.

◂ Back to Identification

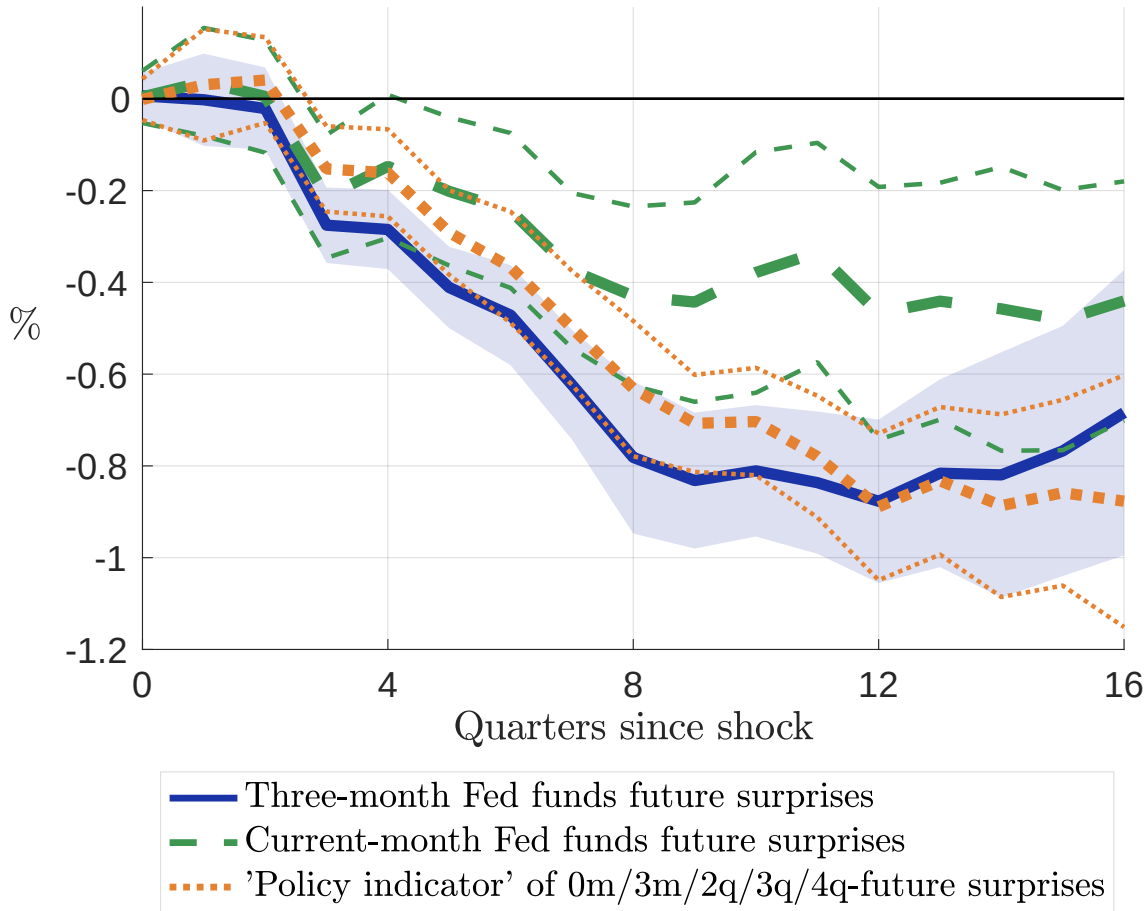
Monetary policy shocks II



Monetary policy shocks at quarterly frequency. Shaded gray areas indicate NBER recession dates.

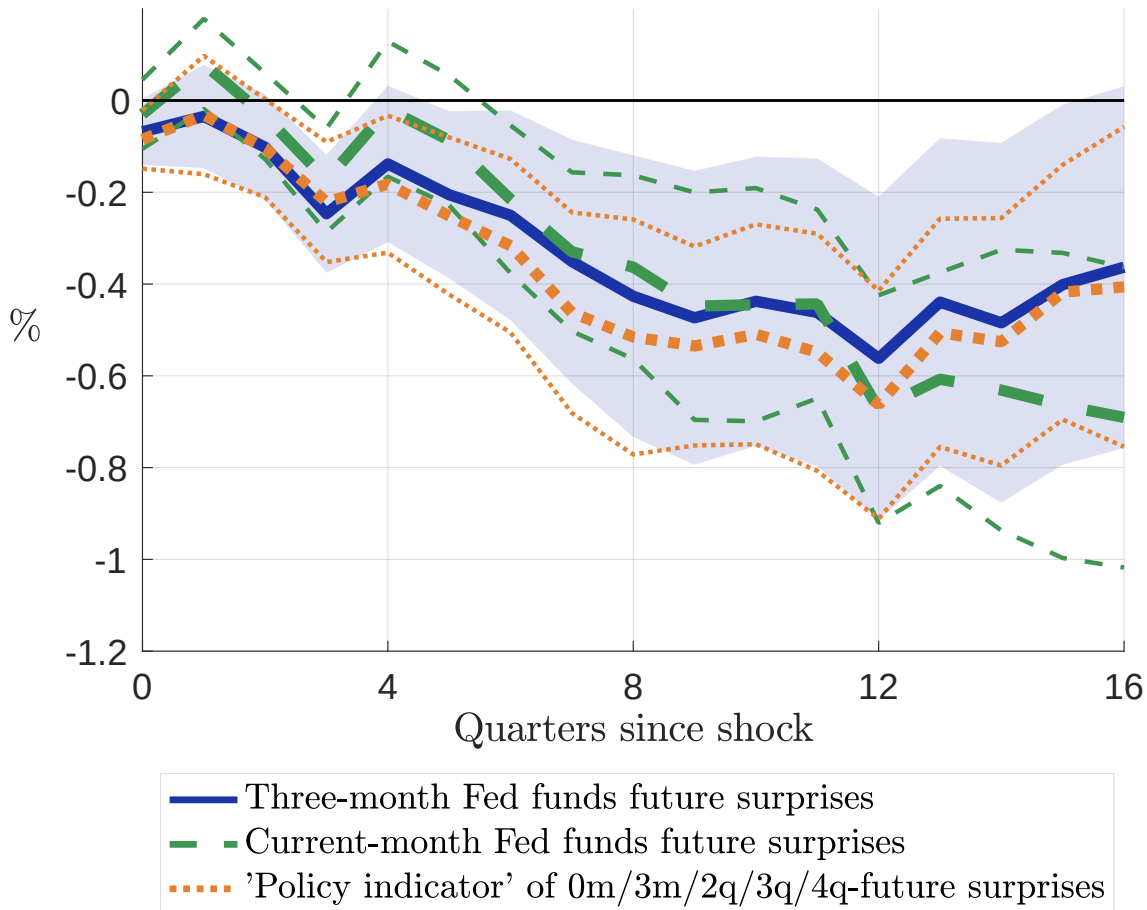
◂ Back to Identification

TFP response for alternative monetary policy shocks I

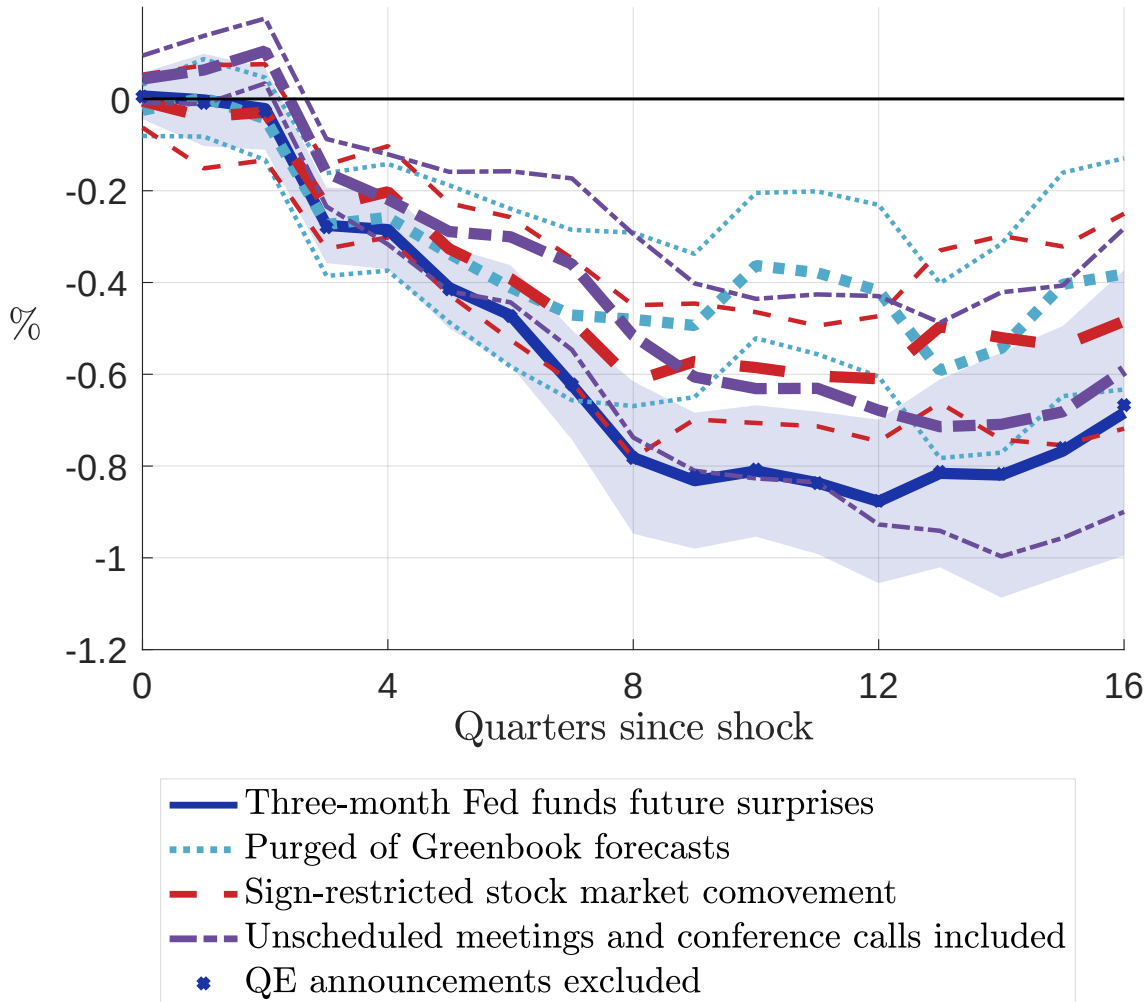


◂ Robustness

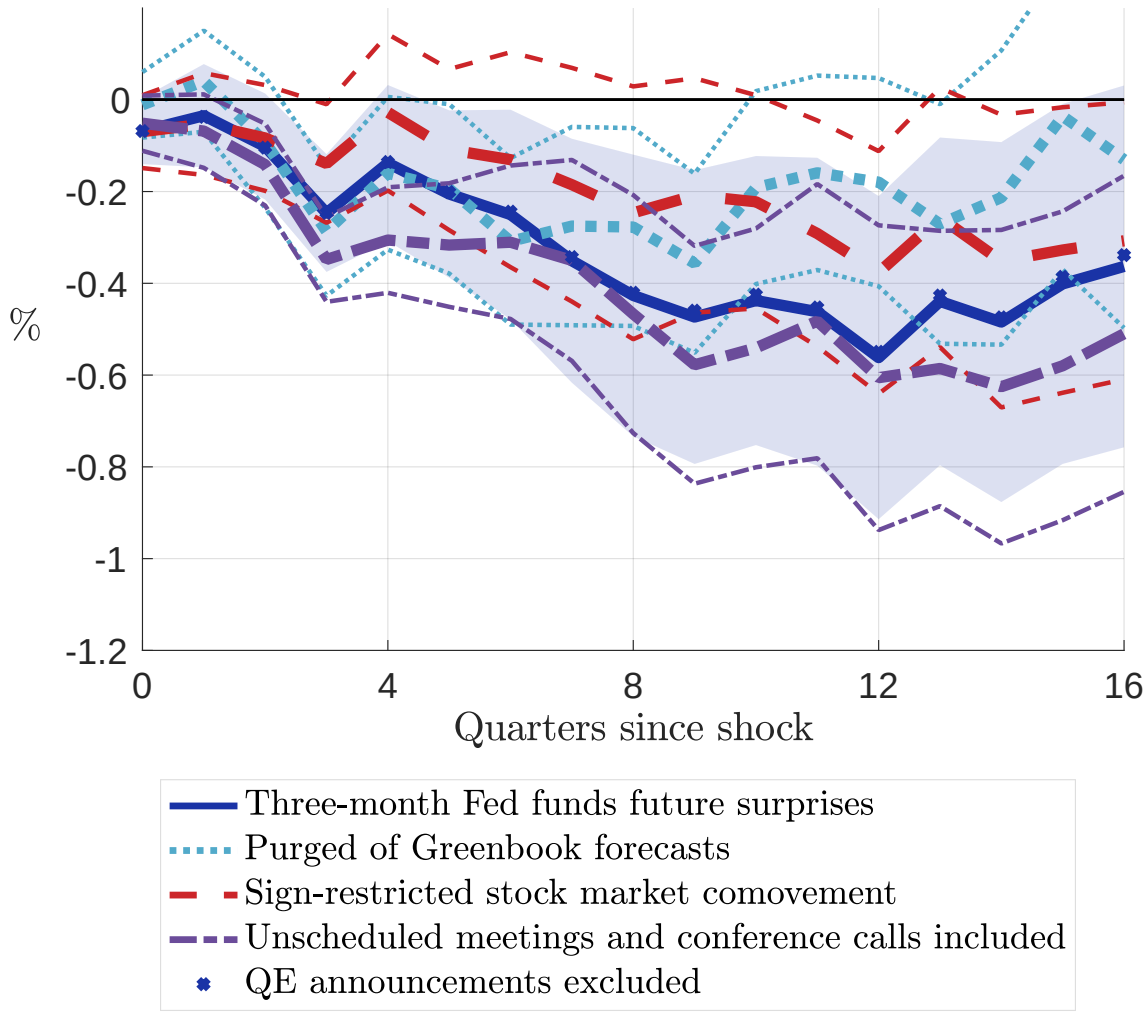
Utilization-adjusted TFP response for alternative monetary policy shocks I



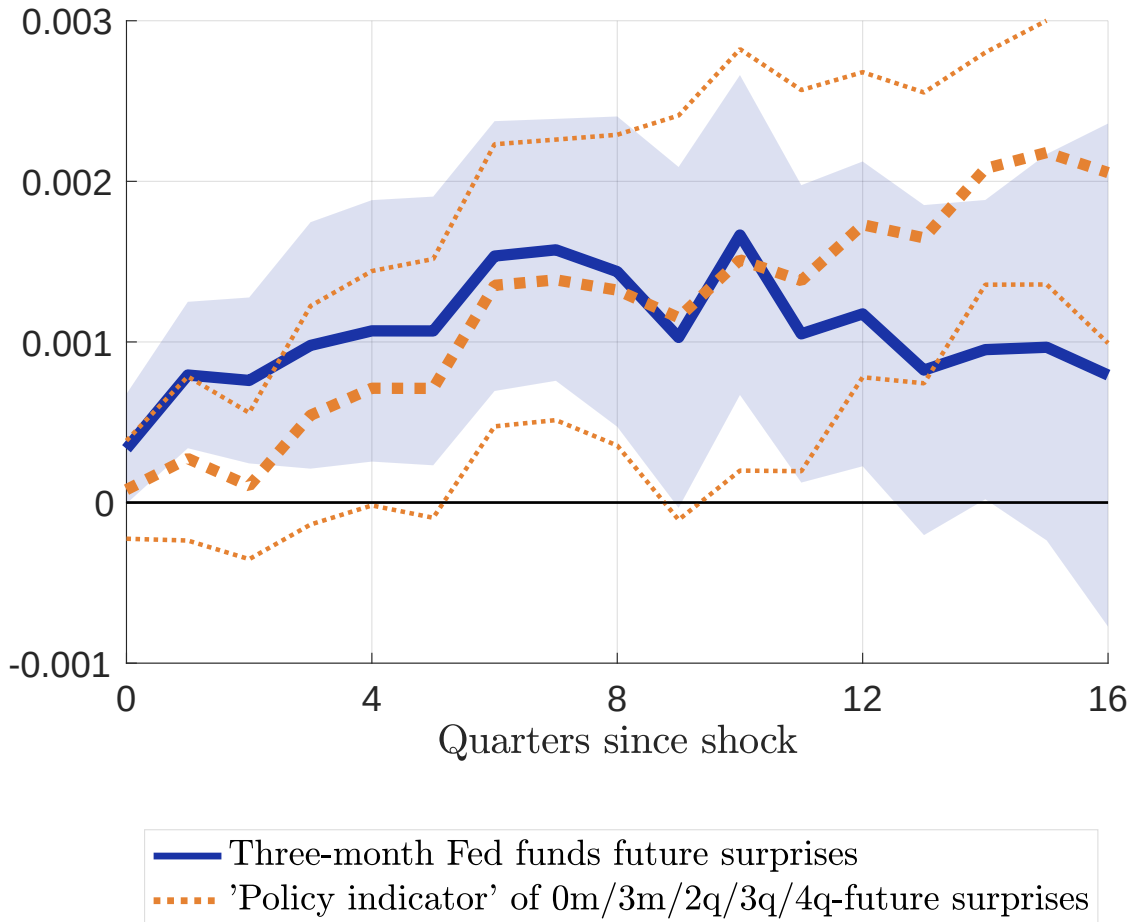
TFP response for alternative monetary policy shocks II



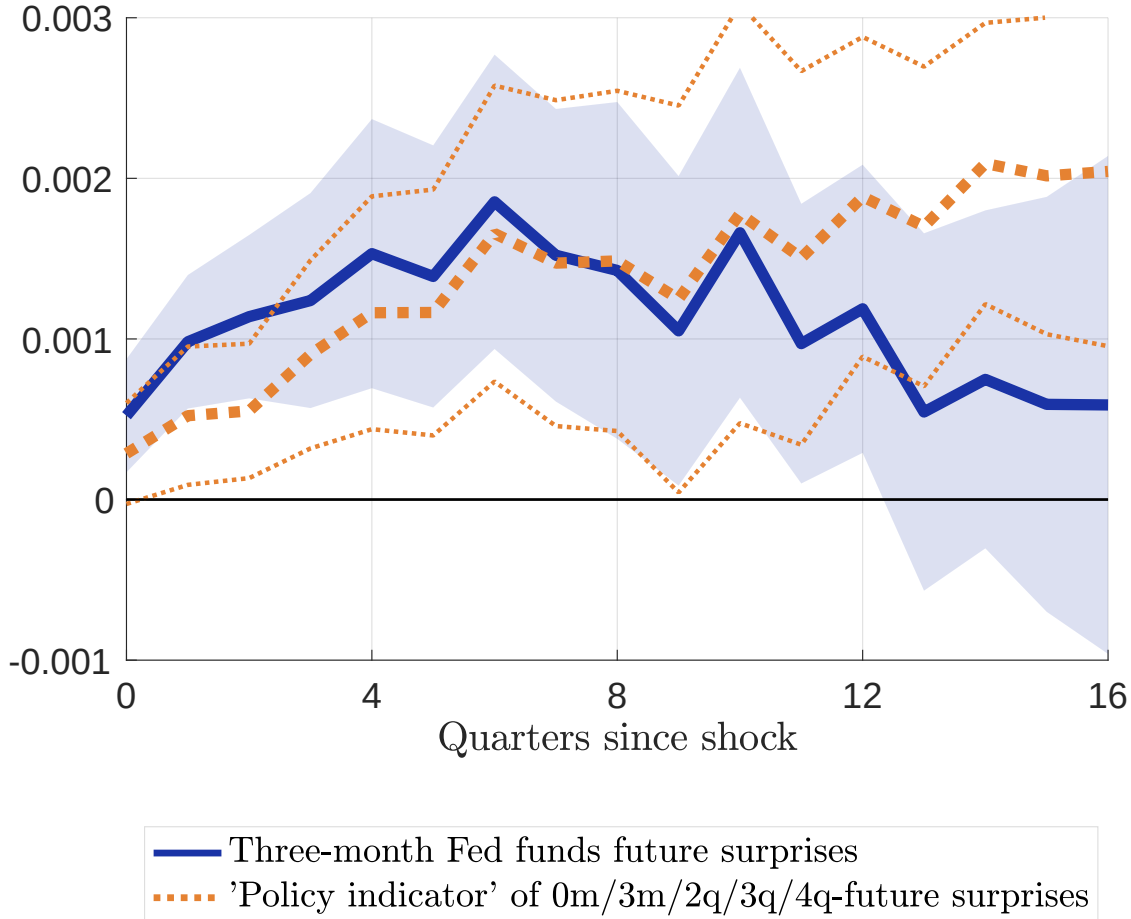
Utilization-adjusted TFP response for alternative monetary policy shocks II



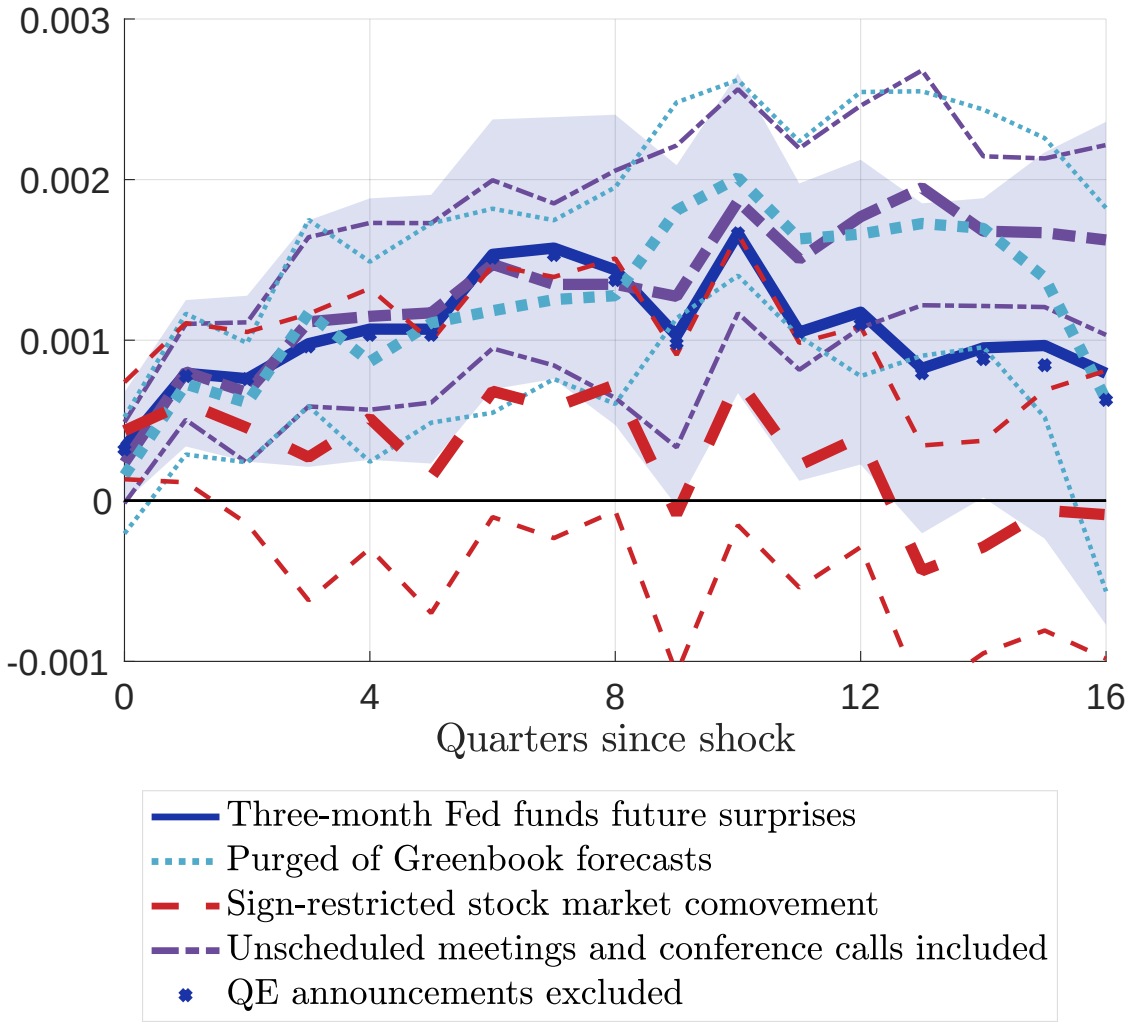
Markup dispersion (2d) response for alternative monetary policy shocks I



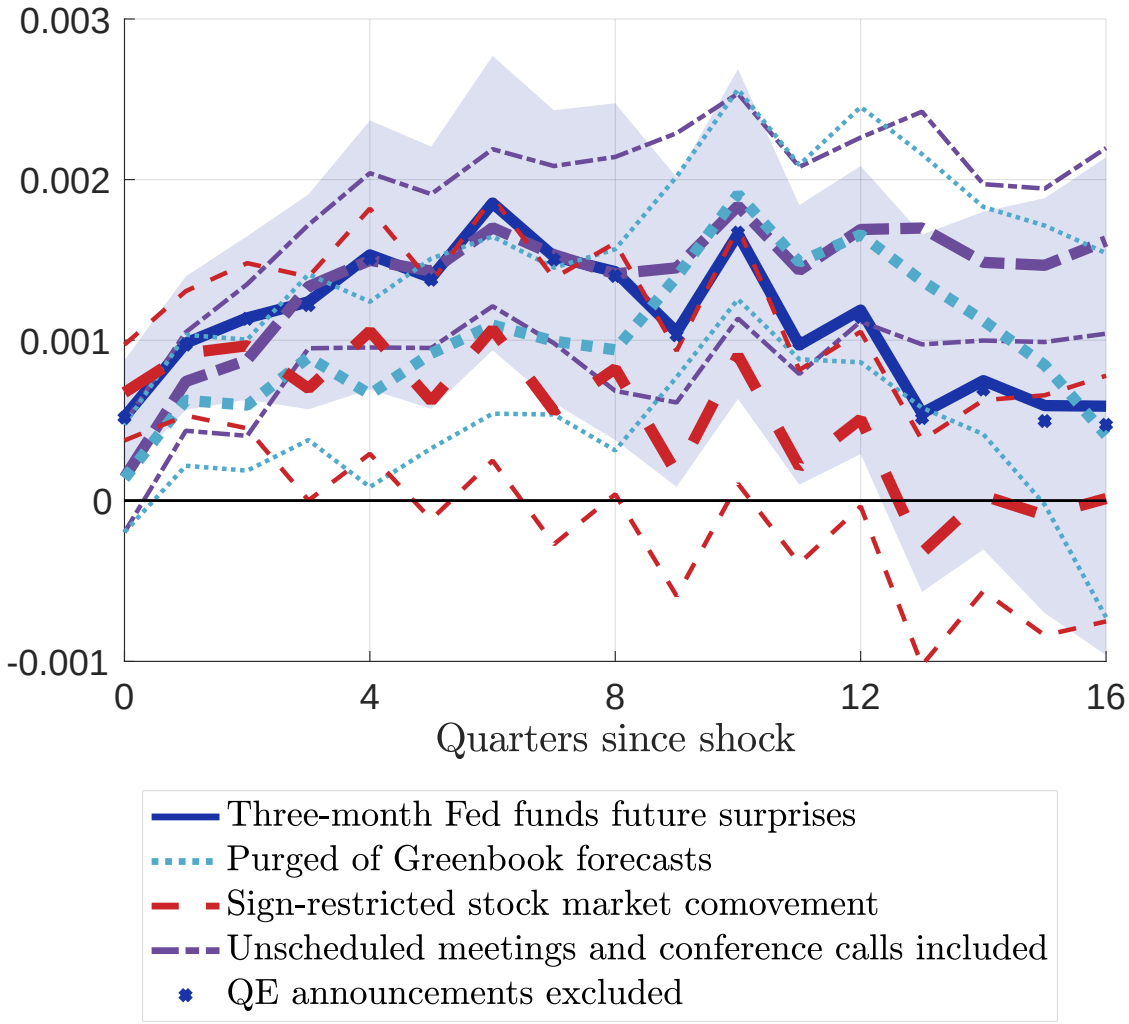
Markup dispersion (4d) response for alternative monetary policy shocks I



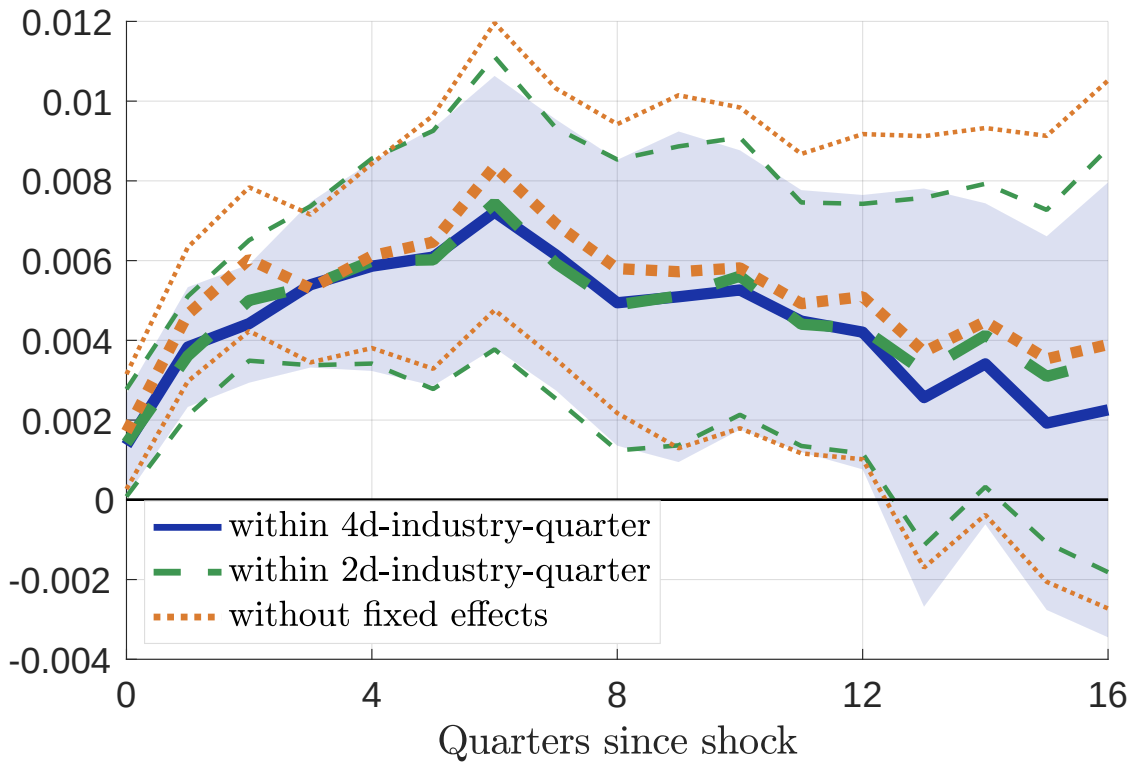
Markup dispersion (2d) response for alternative monetary policy shocks II



Markup dispersion (4d) response for alternative monetary policy shocks II



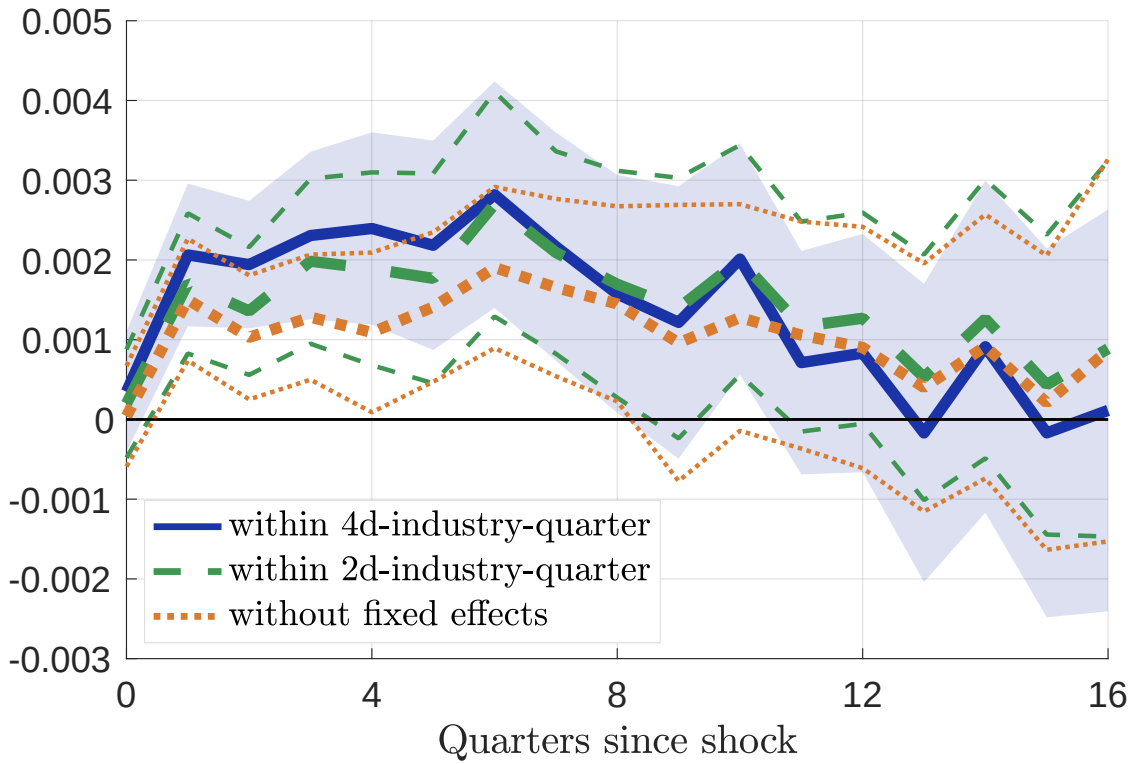
Data treatments: keep firms with sales below 1 mln.



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

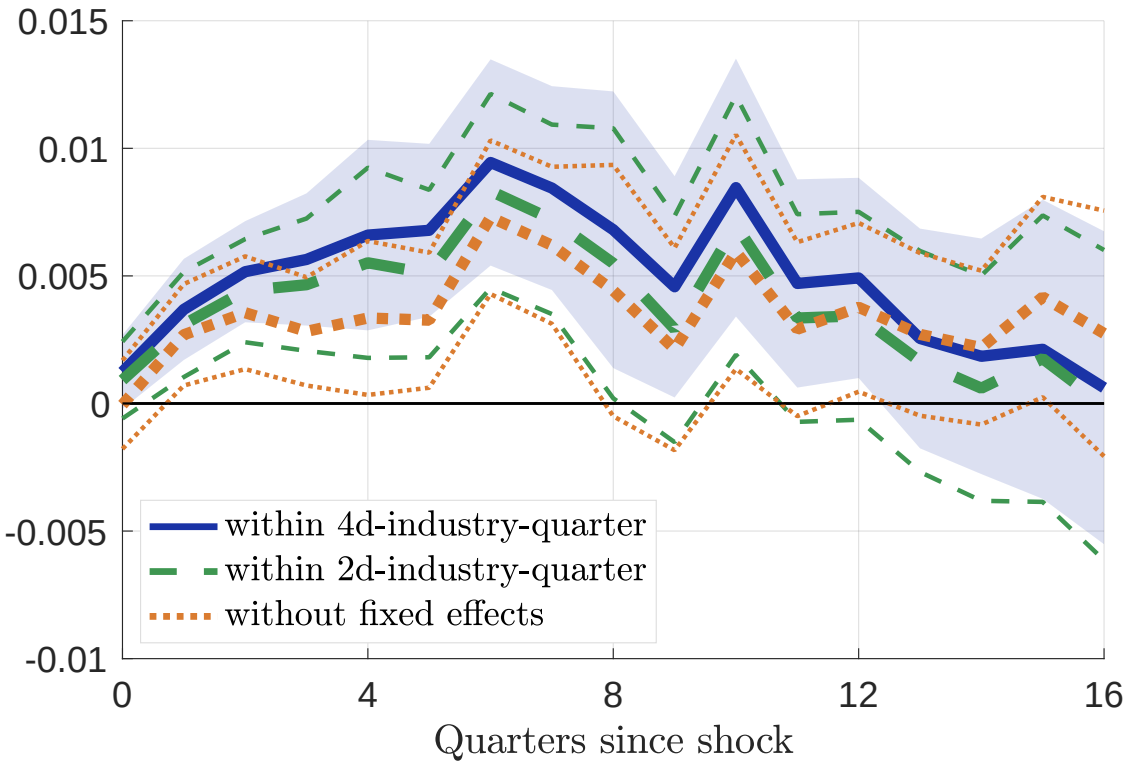
Data treatments: keep firms sales growth below -67% or above 100%



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

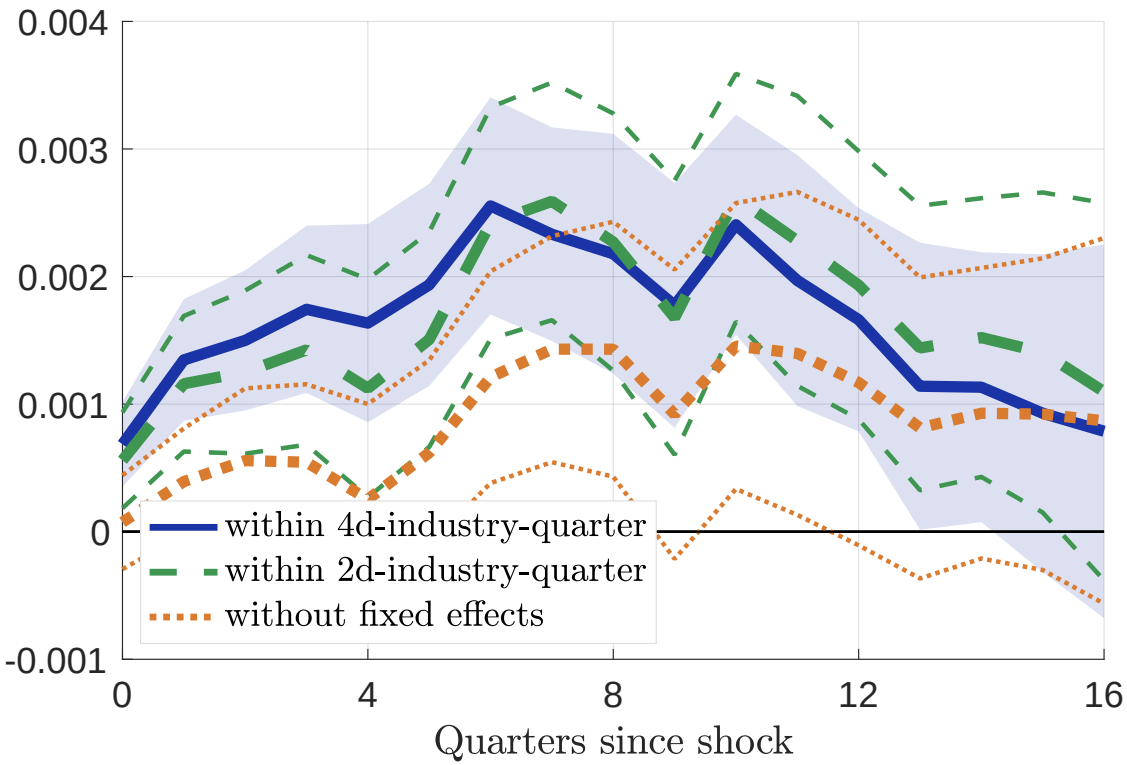
Data treatments: keep top/bottom 5% of markup observations



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

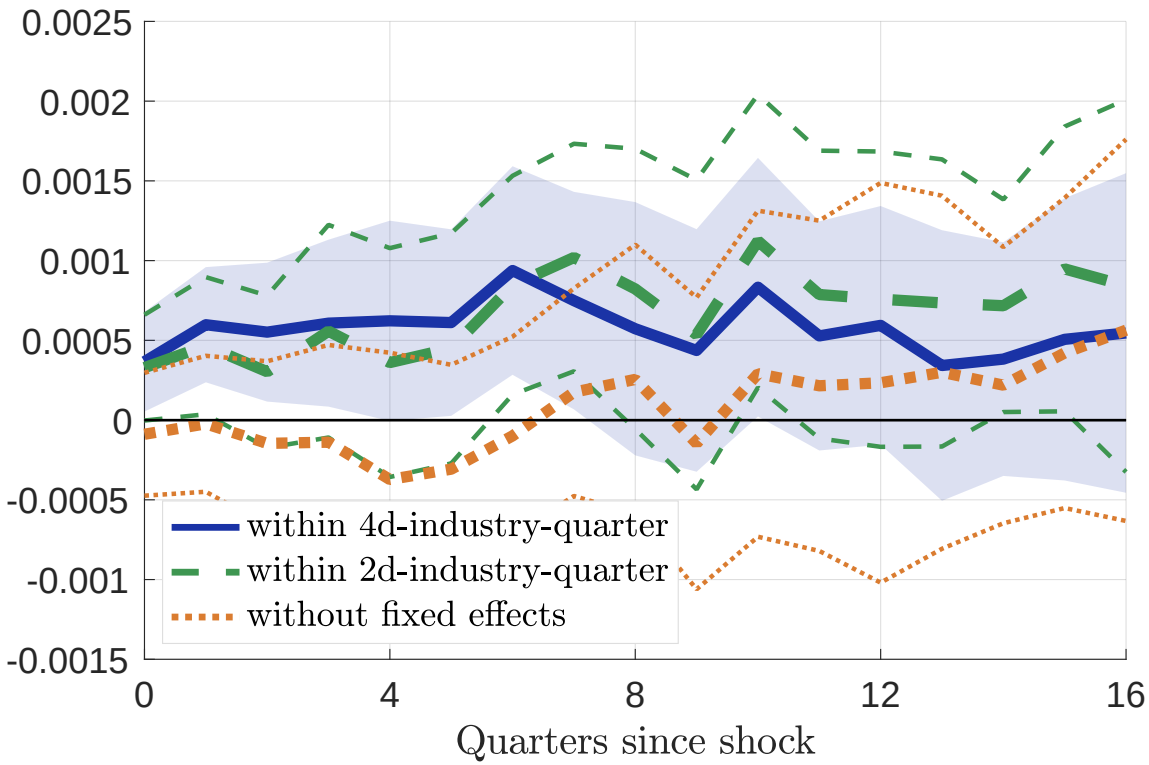
Data treatments: keep Great Recession periods



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

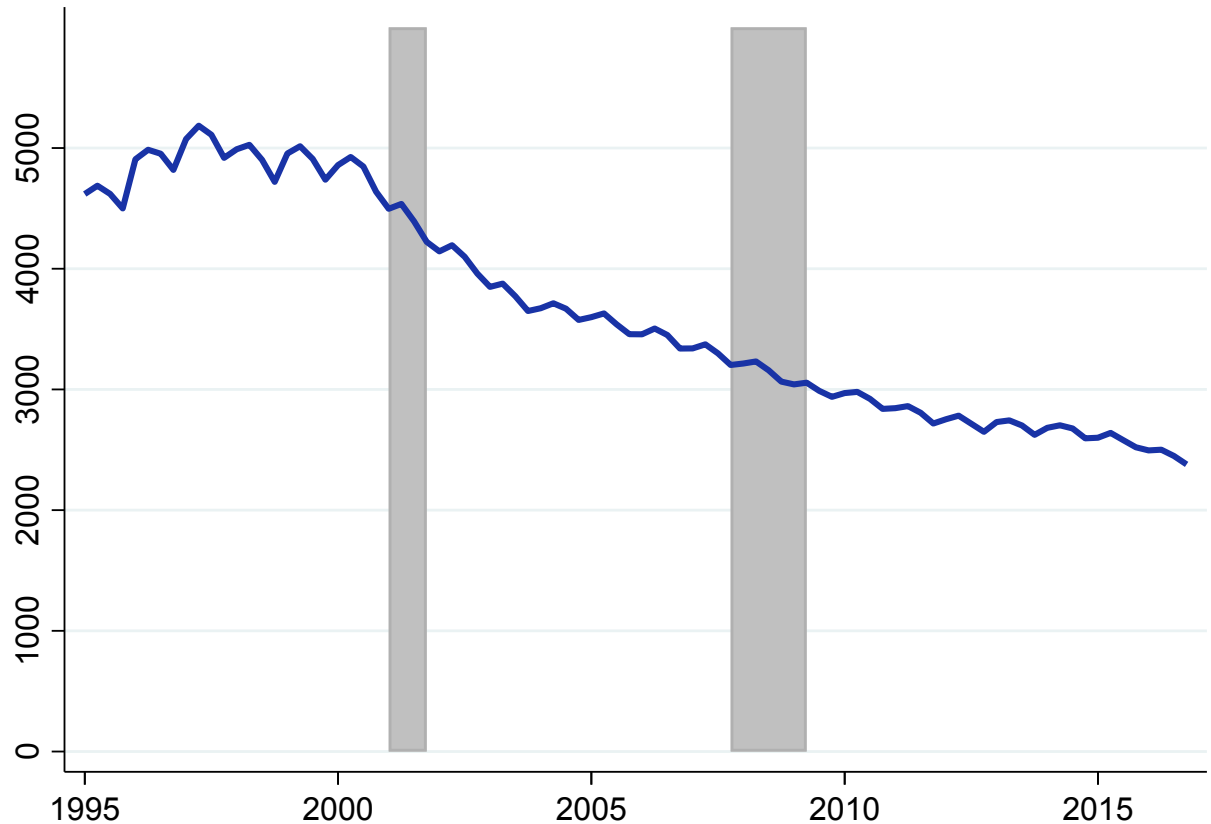
Data treatments: 16 consecutive quarters



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

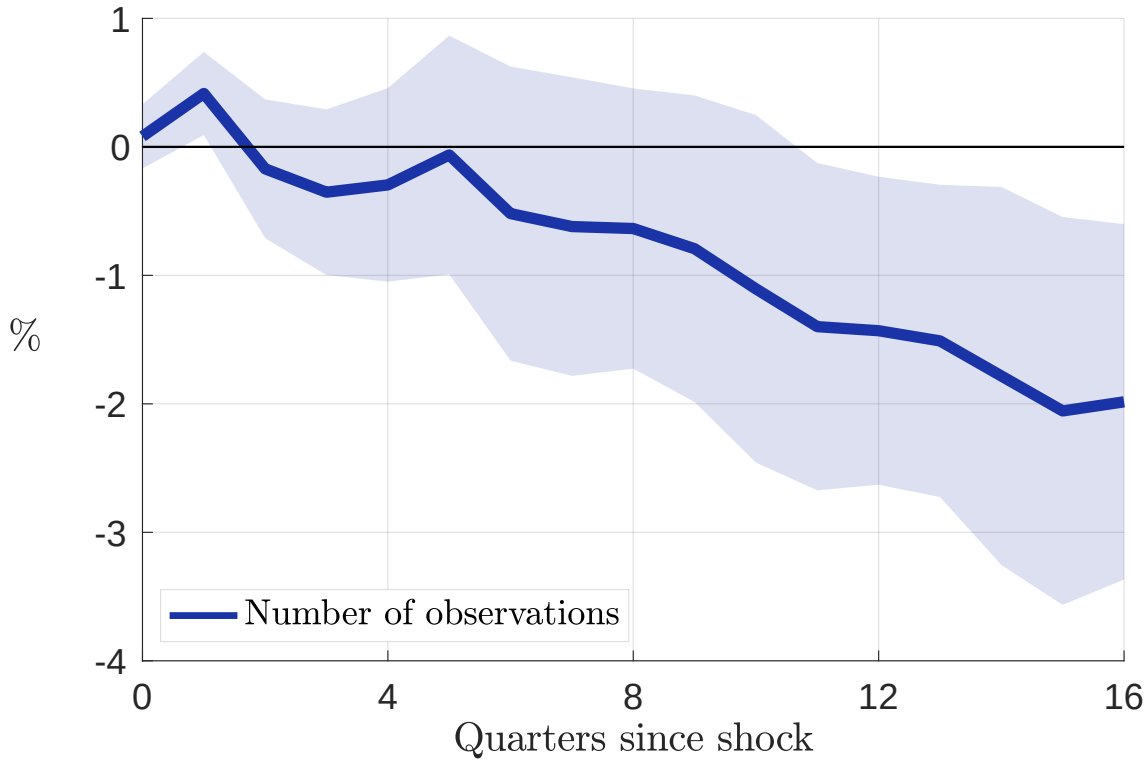
Number of firms over time



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

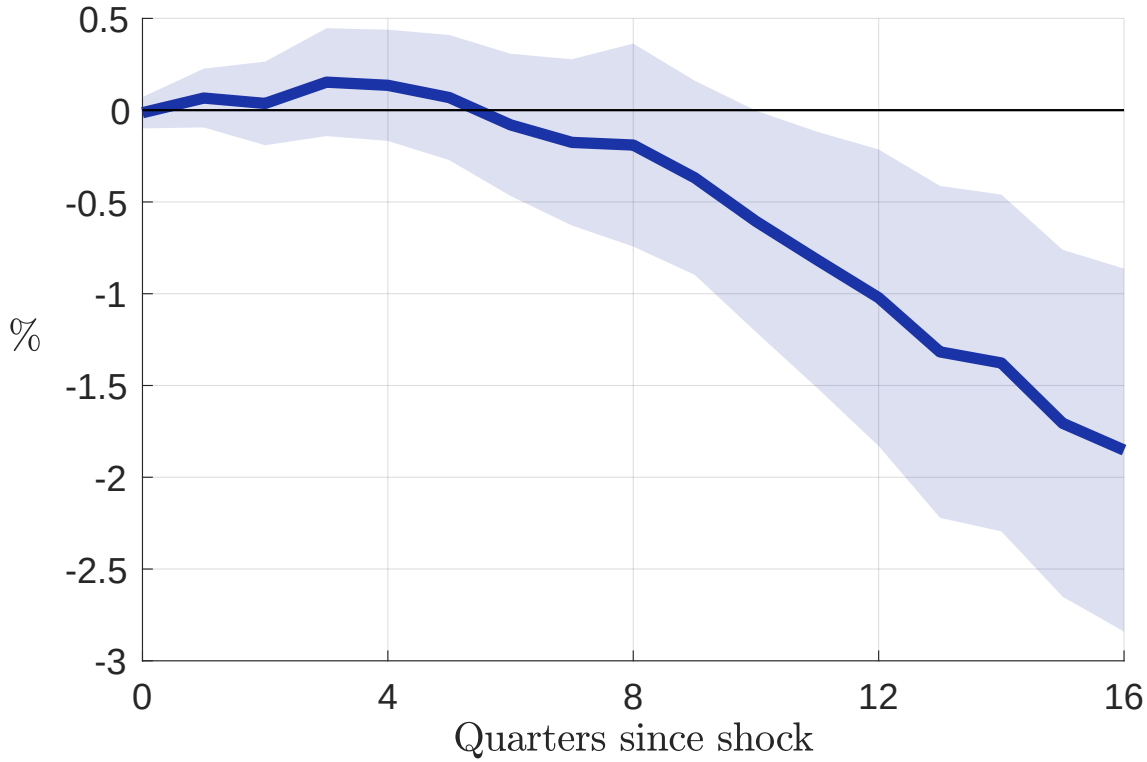
Response of number of firms to shock



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

R&D response



Solid/dashed line: response to a one standard deviation MP shock (increases FFR by up to 30 bp). Shaded area/dotted line: Newey-West one-standard error bands.

◂ Robustness

Parametrization

Utility function: $\log(C_t) - N_t^{1+\varphi}/(1+\varphi)$

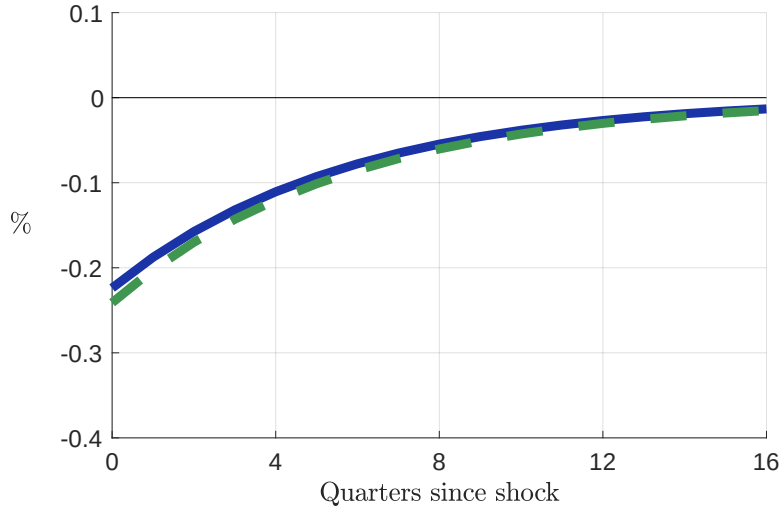
Parameter		Value	Target/Source
Discount factor	β	0.99	Annual rate of 4%
Substitution elasticity	η	6	Christiano-Eichenbaum-Evans (05)
Calvo Parameter 1	θ_1	0	Average price adjustment
Calvo Parameter 2	θ_2	7/8	frequency of 1/4
Taylor rule output coefficient	ϕ_y	1.5	Christiano et al. (2016)
Taylor rule inflation coefficient	ϕ_π	0.05	
Inverse Frisch elasticity	φ	1/0.125	Labor response/output response
MP shock variance	σ_ν	0.58%	Interest rate response

◂ Model

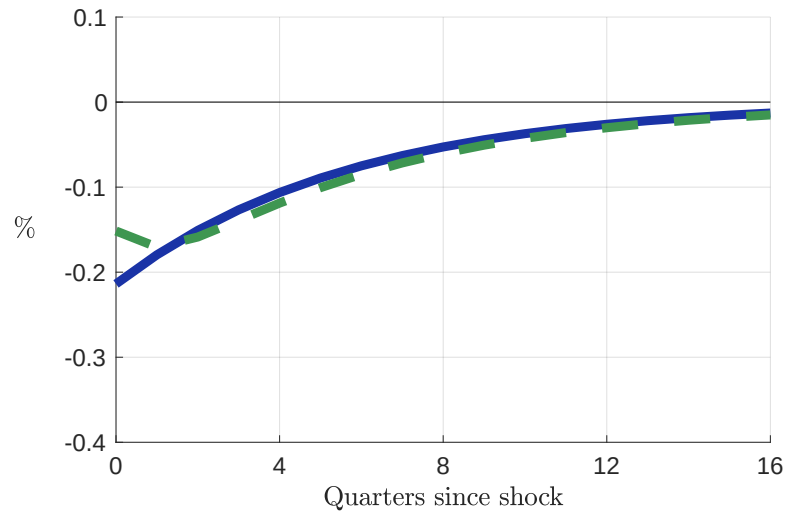
Aggregate productivity shock

(a) Nominal rate

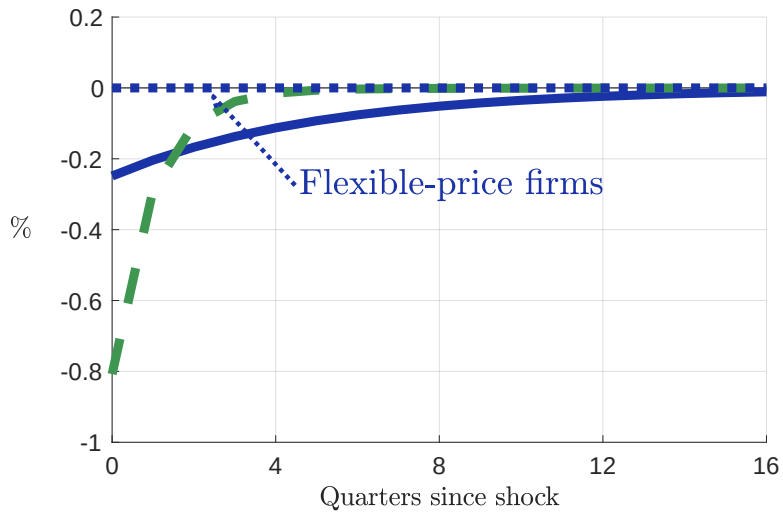
(b) Aggregate TFP



(c) GDP



(d) Markups



Precautionary price setting with Calvo

Heterogeneous Calvo (83) price adjustment probability $1 - \theta_i \in (0, 1)$

Proposition 1 (precautionary price setting)

If $P_t = \bar{P}$, $W_t = \bar{W}$, and

$$(\eta - 1)\sigma_p^2 + \sigma_{py} + \eta\sigma_{pw} + \sigma_{wy} > 0,$$

then the firm optimally sets a higher markup ($\mu_{it} \equiv P_{it}/W_{it}$) than statically optimal, and the markup further increases in θ_i,

$$\mu_{it}^* > \frac{\eta}{\eta - 1}, \quad \text{and} \quad \frac{\partial \mu_{it}^*}{\partial \theta_i} > 0.$$

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Response of markup dispersion

Pass-through from real marginal costs to price: $\varepsilon_{it} \equiv \frac{\mathrm{d} \log P_{it}}{\mathrm{d} \log W_t}$

Proposition 2 (markup dispersion)

Supppose $\mathrm{corr}(\log \mu_{it}, \varepsilon_{it}) < 0$ [satisfied under Proposition 1].
Then markup dispersion decreases in real marginal costs

$$\frac{\partial \mathbb{V}_t[\log \mu_{it}]}{\partial \log W_t} < 0.$$

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Rotemberg friction

Consider quadratic Rotemberg (1982) price adjustment costs, parametrized by a *firm-specific* cost shifter $\phi_i \geq 0$

Similar to Calvo, we provide (weak) conditions under which firm-level heterogeneity in ϕ_i generates a negative correlation between markups and pass-through $\text{corr}(\log \mu_{it}, \varepsilon_{it}) < 0$

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Markup dispersion and aggregate TFP

Aggregate output = CES aggregator

Aggregate TFP = Solow residual

2nd-order approx. of aggr. TFP around $\log \mu_{it} = \log \frac{\eta}{\eta-1}$:

$$\text{TFP}_t \approx -\frac{\eta}{2}\mathbb{V}_t[\log \mu_{it}] + \text{aggregate exogenous productivity}$$

(see Hsieh/Klenow 09, Baqaee/Farhi 19)

$\rightarrow$ higher markup dispersion lowers aggregate TFP

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