THE LONG AND VARIABLE LAGS OF MONETARY POLICY: EVIDENCE FROM DISAGGREGATED PRICE INDICES

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MOTIVATION

- Fed Chair Powell in Jackson Hole (2023):

  "*assessment is further complicated by uncertainty about the duration of the lags with which monetary tightening affects (...) especially inflation.*"

- Classic question: how quickly does inflation respond to monetary policy?

- Approach: study disaggregated price index responses to monetary policy shocks

THIS PAPER - disAGGREGATION

- Local projections for PCE price index subcomponents
  - PCEPI is targeted by the Fed
  - Can split into up to 136 price series consistently through time
- Focus on "traditional" interest rate policy in 1982-2008 sample
  - Use clean measure of identified shocks (Aruoba and Drechsel, 2023)

THIS PAPER - reAGGREGATION

- "Re-aggregate" cross-sectional estimates
  - Can use actual or counterfactual consumption expenditure compositions
  - How would inflation respond with today's expenditure shares?
- Technical contribution: local projections as seemingly unrelated regressions (SUR)
  - Standard errors account for dependence between individual price IRFs
  - Method applicable to other local projection settings with aggregation (e.g. firms)

PREVIEW OF FINDINGS

1. After monetary contraction, PCEPI turns significantly negative after 3+ years

2. Aggregate response masks "variable lags" across individual price categories
   - Many respond with long delay; some even positive; some quickly; some never
   - Only after several years, decline is broad-based across price categories

3. Theoretical interpretation
   - Many price adjustment theories cannot explain the patterns we find

4. SUR re-aggregation with counterfactual expenditure shares similar to actual IRF
   - Changes in expenditure shares have not accelerated the PCEPI response

CONTRIBUTION

1. Effects of monetary policy shocks survey by Ramey (2016)
2. Macro papers with micro price data surveys by Klenow and Malin (2010), Nakamura and Steinsson (2018)

→ Intersection of 1. and 2. Boivin, Giannoni, and Mihov (2009), Baumeister, Liu, and Mumtaz (2013), ...

Contribution: use local projections, clean shocks, traditional monetary policy

3. Econometric inference with local projections, including in panel settings

Plagborg-Moller and Wolf (2021), Montiel Olea and Plagborg-Moller (2021), Lusompa (2023), Almuzara and Sancibrián (2024), ...

Contribution: SUR with cross-sectional dependence of heterogeneous IRFs

METHODOLOGY

LOCAL PROJECTIONS FOR PRICE SUBCOMPONENTS

$$\log p_{i,t+h} = \alpha_{i,h} + \beta_{i,h}\hat{\varepsilon}_t^m + \gamma_i X_{i,t} + u_{i,t+h}$$

- $p_{i,t+h}$: price of PCEPI subcomponent $i = 1, ..., N$ at horizon h
- N depends on level of disaggregation (2, 4, 17, 68 or 136)
- $\hat{\varepsilon}_t^m$ identified monetary policy shock (Aruoba and Drechsel, 2023)
  - Builds on Romer and Romer (2004)
- $X_{i,t}$ controls → select using 'combinatorial' approach details
- Make HAC adjustment to standard errors with bandwidth $h + 1$
- Sample is 1982-2008 → "traditional" interest rate policy

RE-AGGREGATION OF IRFS

- Suppose aggregate PCEPI is

$$P_t = \sum_i^N \omega_{i,t} p_{i,t}$$

- Can run individual local projections and obtain the aggregated IRF estimate

$$\hat{\mathcal{B}}_h^{agg} = \sum_i^N \omega_{i,t} \hat{\beta}_{i,h}$$

- Can also use other weights, e.g. 2023 weights to get IRF estimate

$$\hat{\mathcal{B}}_h^{agg,2023} = \sum_i^N \omega_{i,2023} \hat{\beta}_{i,h}$$

SUR/GLS APPROACH

- Econometric challenge
  - Expect estimates of $\beta_{i,h}$ and $\beta_{j,h}$, to be correlated $\rightarrow$ true in macro models
  - Need to obtain appropriate covariance estimates
  - Not possible with separate OLS estimators
- Solution
  - Model local projection for $i = 1, ..., N$ as Seemingly Unrelated Regressions (SUR)
  - Estimate with Feasible Generalized Least Squares (GLS)

SUR/GLS APPROACH FORMALLY

- Define stacked system for each horizon h:

$$\log \boldsymbol{p}_h = \tilde{\boldsymbol{X}} \boldsymbol{\Gamma}_h + \boldsymbol{u}_h$$

- Allow for dependence in the i-dimension: $\mathbb{E}[\boldsymbol{u}'_{i,h} \boldsymbol{u}_{j,h}] = \sigma_{ij,h}$ and $\boldsymbol{\Sigma}_h = \{\sigma_{ij,h}\}$
- Estimate stacked system via FGSL, with weighting matrix $(\hat{\boldsymbol{\Sigma}}_h \otimes \boldsymbol{I}_T)^{-1}$
- Correct standard errors of re-aggregated IRF include covariance terms

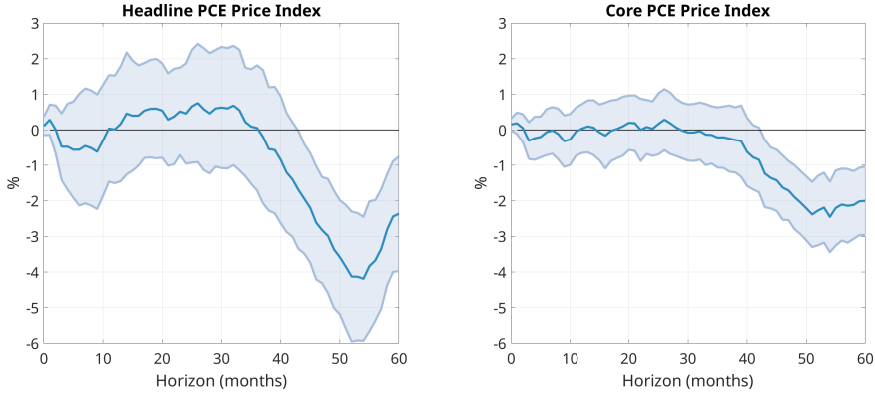
$$SE(\hat{\mathcal{B}}_h^{agg})^{SUR} = \sqrt{\sum_i^N \omega_i^2 \hat{\sigma}^2_{\hat{\beta}^{FGLS}_{i,h}} + \sum_i^N \sum_{j \neq i}^N \omega_i \omega_j \hat{\sigma}_{\hat{\beta}^{FGLS}_{i,h}, \hat{\beta}^{FGLS}_{j,h}}}$$

discussion

RESULTS - AGGREGATE

AGGREGATE PCEPI RESPONSE

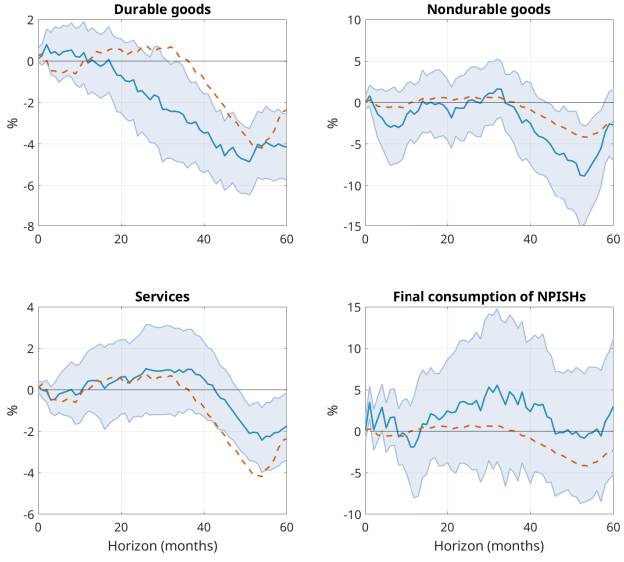
LITERATURE



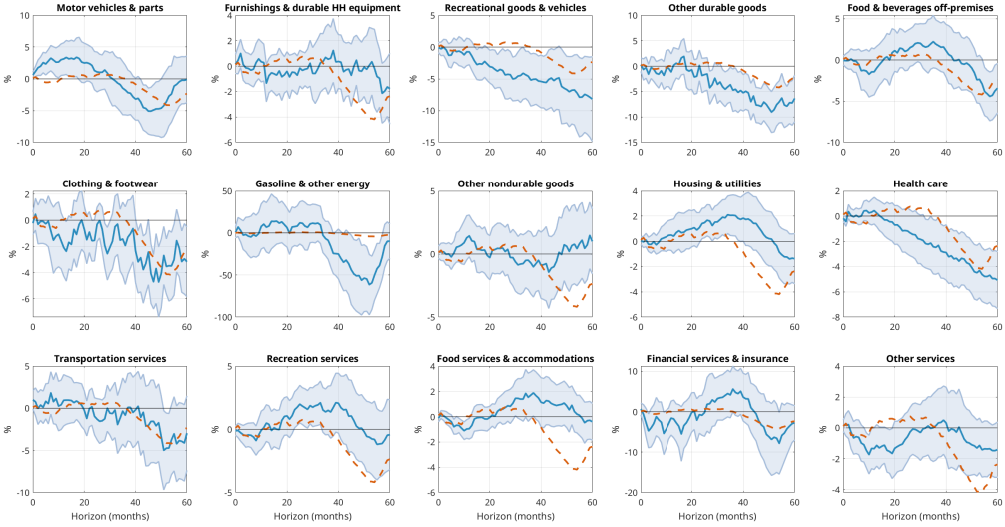
- Peak price level reduction of 4% to 100bp tightening after 54 months
- Similar lag structure for headline and core PCEPI

RESULTS - disAGGREGATION

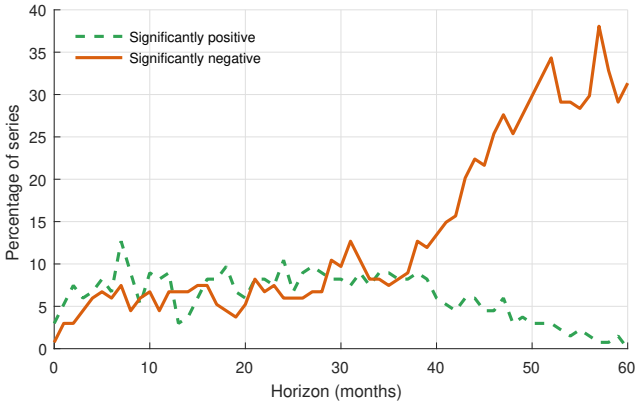
RESPONSES OF SUBCOMPONENTS - LEVEL 2



RESPONSES OF SUBCOMPONENTS - LEVEL 3 STD



RESPONSES OF SUBCOMPONENTS - LEVEL 5 INTENSIVE



- Aggregate IRF flat for several years *not* because all prices are unchanged
- On the contrary: heterogeneity makes it hard to get a clean response early

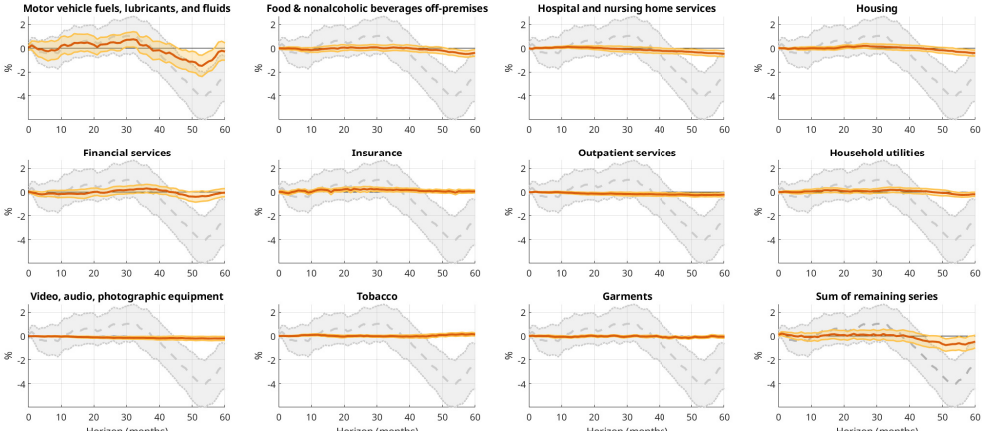
RESPONSES OF CONTRIBUTIONS FORMULA

- PCEPI is not a weighted average but a chain-linked Fisher index
- BEA also provides data on each components contribution to PCEPI inflation $con_{i,t}$

$$\Delta P_t = \sum_{i}^{N} con_{i,t},$$

- Can recursively define $con_{i,t} = \Delta m_{i,t}$ and study IRF of $m_{i,t+h}$
- 'Contribution IRF' is large when a combination of three factors occurs:
  - (I) a large response in the price series
  - (II) a large increase in the weight of the price series
  - (III) a great initial weight in the PCEPI

RESPONSES OF CONTRIBUTIONS

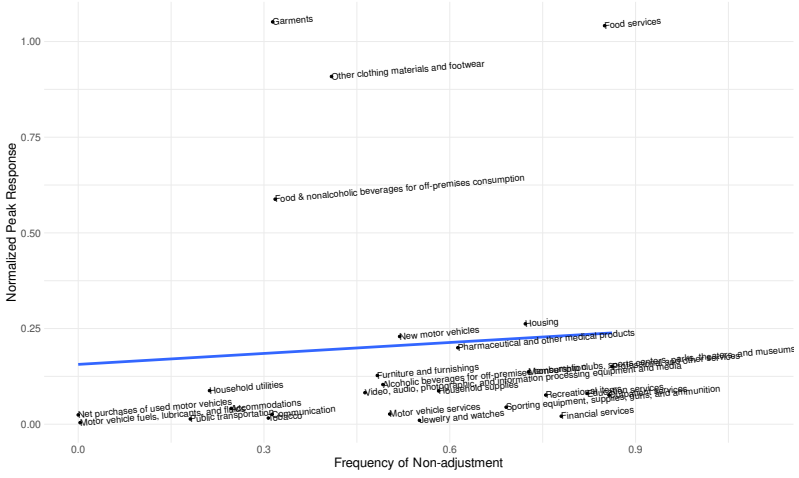


- A few components have a disproportionately large effect on the aggregate response
- These components all show a similar lagged pattern

INTERPRETING OUR CROSS-SECTIONAL RESULTS

- Can theories of price adjustment explain positive & negative & flat patterns?
  - Calvo? No
  - Menu costs? No
  - Sticky or noisy information? No
- Best candidates
  - Cost channel of higher nominal rates, heterogeneous across sectors
  - Strong demand substitution across sectors at short horizons
- The paper provides an in-depth discussion

INTERPRETING OUR CROSS-SECTIONAL RESULTS

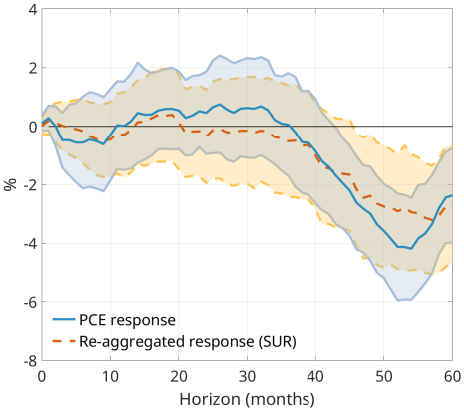


- Calvo model would predict clear negative relation

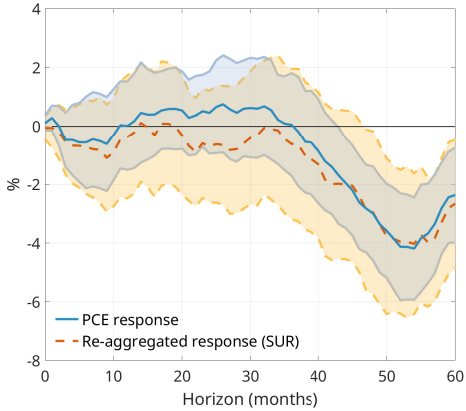
RESULTS - reAGGREGATION

RE-AGGREGATION WITH DIFFERENT YEAR WEIGHTS - LEVEL 5

1959

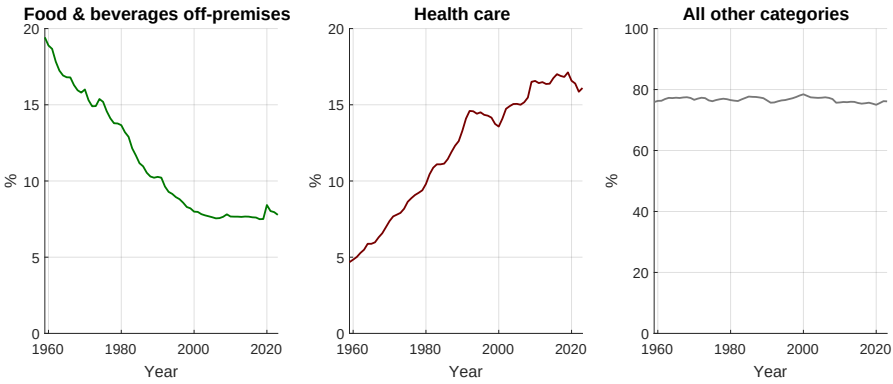


2023



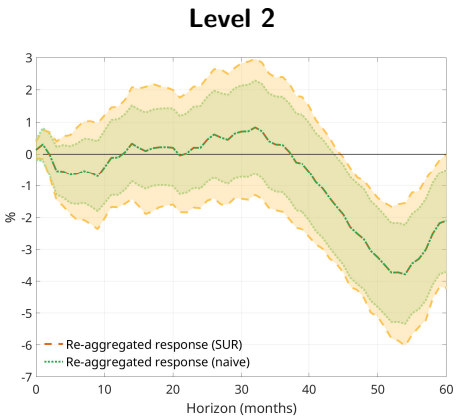
- Changes in expenditure shares have not accelerated the PCEPI responses
- Similar message for re-aggregation of different levels or core level 3 core

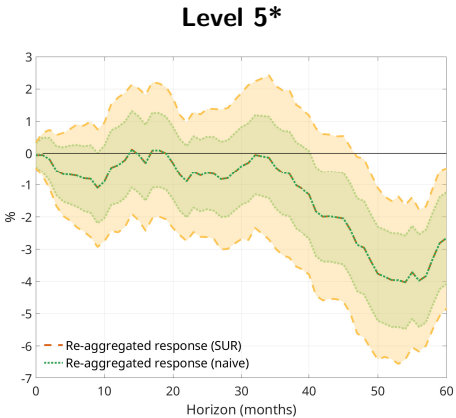
CHANGES IN SHARES



- Main changes in expenditure shares of categories with similar IRFs

RE-AGGREGATION 2023 - NAIVE VS. SUR

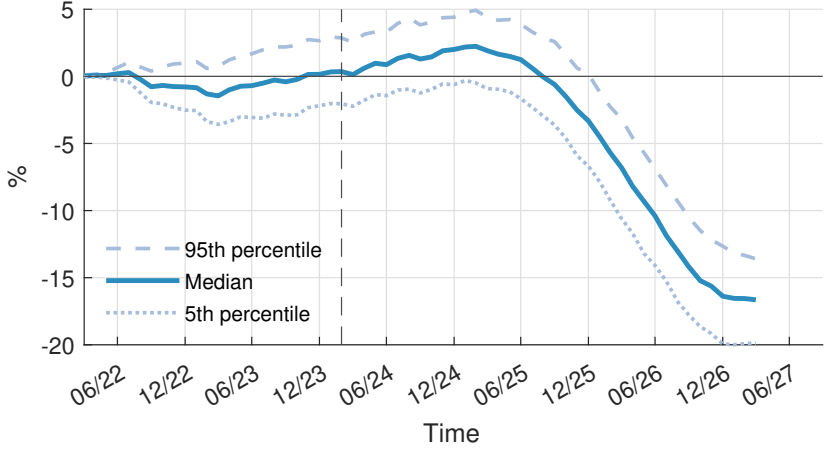




- When ignoring covariance terms, one obtains misleadingly precise estimates

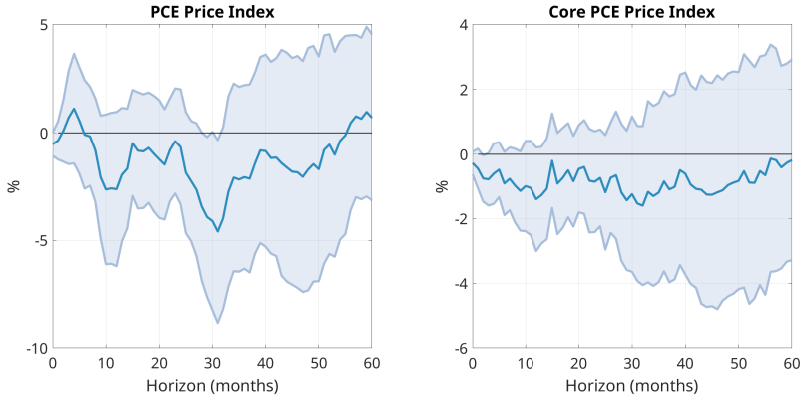
DISCUSSION

ARE 2022-23 FED HIKES ALREADY REFLECTED IN THE DATA?



- Provocative calculation: *none* of the Fed's hikes are currently reflected in the data

ARE THE EFFECTS STRONGER WHEN INFLATION IS HIGH?



- In above-median inflation periods, response gets much more negative
- Imprecisely estimated, but significant at 2.5 year horizon
- We also checked for asymmetric effects and could not detect any asymmetries

CONCLUSION

CONCLUSION

- Classic question in macroeconomics: how do prices react to monetary policy?
- We use local projections and disaggregated price indeces to revisit it
  - Technical contribution: LPs as SUR
- Results show that "long and variable lags" Friedman (1960, 1961) alive and well
  - "Variable" across different price components
- **Response of inflation to 2022-23 Fed hikes not yet fully reflected in data?**

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APPENDIX SLIDES

SELECTION OF CONTROLS IN LOCAL PROJECTIONS

BACK

- With an exogenous shock, do not need controls for regression to be valid
- But controls matter in small samples (Plagborg-Moller and Wolf, 2021)
- Combinatorial approach:
  - Always include constant, one lag of the LHS variable, the shock and two lags
  - Choose up 70 controls that maximize fit at horizon $h = 24$
  - Select among 2,404,808,340 regressions for each local projection

SUR/GLS APPROACH: DISCUSSION BACK

- We could additionally stack the system in the h dimension
  - Suggested to account for serially correlated errors in *individual* LPs (Lusompa, 2023)
  - To address that issue, we additionally make HAC adjustment to our system
- Approach relates to panel local projections, e.g. Ottonello and Winberry (2020)
  - Typically, same β^h across cross-sectional units + some categorical interaction
  - Here, different β_i^h for each i
  - Our re-aggregation procedure might also be relevant for firms or households
    - e.g. response of total firm investment to monetary policy

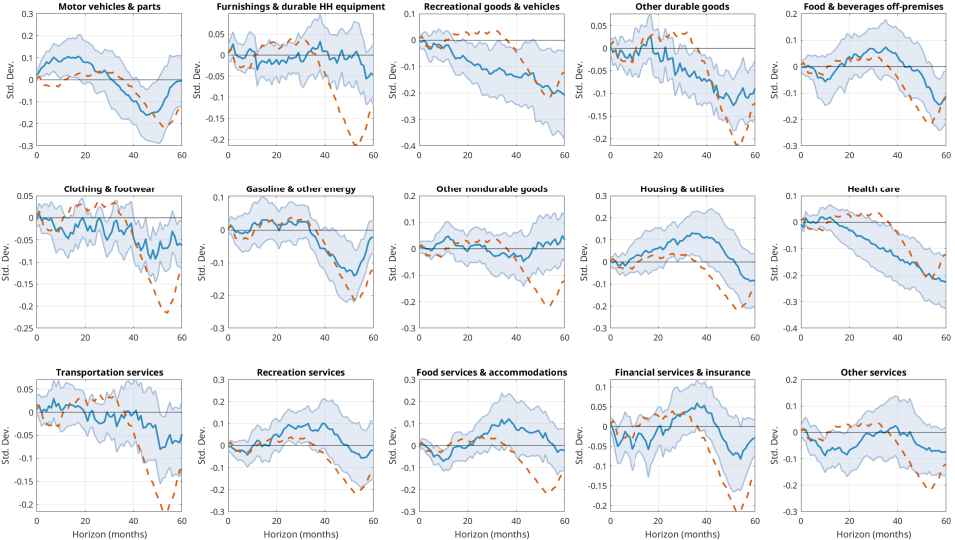
LAGS IN THE LITERATURE

BACK

Paper	Estimator	Identification Type	Sample	Peak Response	First Negative
Jorda et al (JME, 2020)	LP-IV	Greenbook	1870 – 2006	48 (final)	27
Auclert et al (2020)	LP	Greenbook	1969:3 – 1996:12	60 (final)	44
Aruoba & Drechsel (2023)	BVAR	Greenbook	1984:2 – 2016:12	35	–
Gertler & Karadi (2015)	Proxy SVAR	High-frequency surprise	1979:7 – 2012:6	42	32
Kekre & Lenel (2022)	Proxy SVAR	High-frequency surprise	1979:7 – 2012:6	45	0
Gagliardone & Gertler (2023)	Proxy SVAR	High-frequency surprise	1973:1 – 2019:12	32	0
Jarocinski & Karadi (2020)	VAR	Sign-restricted HF	1990 – 2006	30	1
Swanson (2023)	VAR	HF surprise	1973 – 2008	20	0
Bauer & Swanson (2023)	Proxy SVAR	HF surprise	1979:7 – 2012:6	35	0
Miranda-Agrippino & Ricco (2021)	Proxy SVAR	HF surprise	1972:1 – 2014:12	24 (final)	0
Miranda-Agrippino & Ricco (2021)	Proxy SVAR	Narrative	1972:1 – 2014:12	6	–
Miranda-Agrippino & Ricco (2021)	Proxy SVAR	Informationally robust	1972:1 – 2014:12	24 (final)	0
Kaminska et al (2021)	Bayesian LP	HF surprise	1990 – 2007	0	–
Bu et al (2021)	SVAR	Fama and MacBeth (1973)	1994 – 2017	8	6
Bu et al (2021)	LP	Fama and MacBeth (1973)	1994 – 2017	8	6
Bernanke et al (2005)	FAVAR	Bernanke et al. (2005)	1959:1 – 2001:8	48	–
Adamek et al (2024)	High-dimensional LP	Bernanke et al. (2005)	1969:1 – 2008:10	20	48 (final)
Adamek et al (2024)	FAVAR	Bernanke et al. (2005)	1969:1 – 2008:10	50 (final)	50 (final)
Ramey (2016) replications:					
Christiano et al. (1999)	VAR	Recursive VAR	1965:1 – 1995:6	48 (final)	11
Coibon VAR	VAR	Narrative	1969:3 – 1996:12	42	11
Romer & Romer	LP	Narrative	1969:3 – 1996:12	48 (final)	35
Proxy SVAR	Proxy SVAR	Narrative	1969:3 – 2007:12	25	–
Gertler & Karadi SVAR	Proxy SVAR	HF surprise	1979:7 – 2012:6	38	24
Gertler & Karadi	LP	HF surprise	1990:1 – 2012:6	41	41

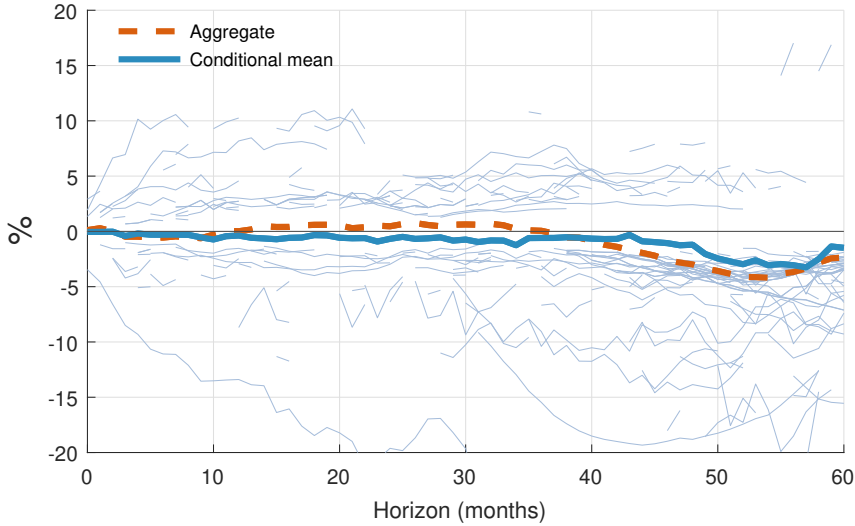
RESPONSES OF SUBCOMPONENTS - LEVEL 3

BACK



SIGNIFICANT IRFS - LEVEL 5

BACK



FULL FORMULA FOR CONTRIBUTIONS

BACK

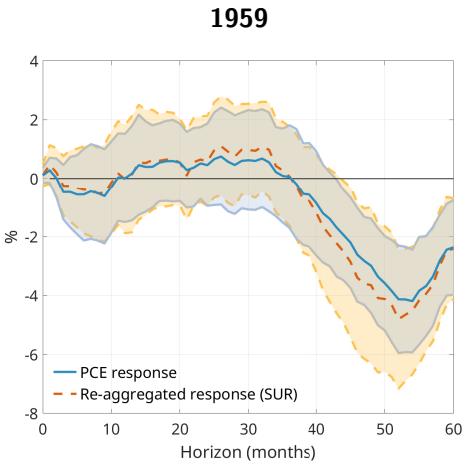
For each price series i, we compute the contribution to PCEPI inflation between periods t and $t+q$ using the additive disaggregation proposed by Reinsdorf et al. (2002):

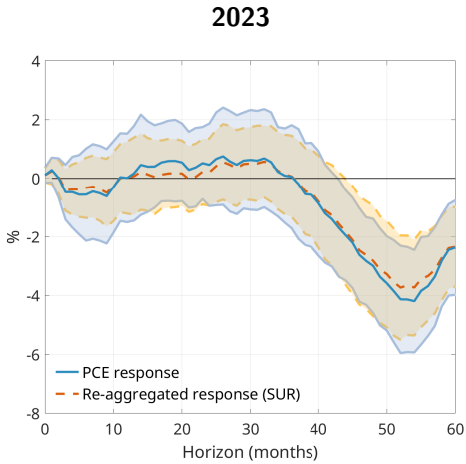
$$con_{i_t}^{q} = \frac{q_{it} + q_{it+q}(P_F/Q_F)}{\mathbf{p}_t'\mathbf{q}_t + (\mathbf{p}_t'\mathbf{q}_t)P_F}(p_{it+q} - p_{it}),$$

where p_{it}, q_{it} are component i's price and quantity in period t, bold letters represent vectors of prices or quantities, and P_F and Q_F are the price and quantity Fisher indices, respectively. The Fisher indices are $P_F = \sqrt{(\mathbf{p}_{t+q}'\mathbf{q}_t/\mathbf{p}_t'\mathbf{q}_t)(\mathbf{p}_{t+q}'\mathbf{q}_{t+q}/\mathbf{p}_t'\mathbf{q}_{t+h})}$ and $Q_F = \sqrt{(\mathbf{p}_t'\mathbf{q}_{t+q}/\mathbf{p}_t'\mathbf{q}_t)(\mathbf{p}_{t+q}'\mathbf{q}_{t+q}/\mathbf{p}_{t+q}'\mathbf{q}_t)}$.

RE-AGGREGATION FOR LEVEL 3

BACK

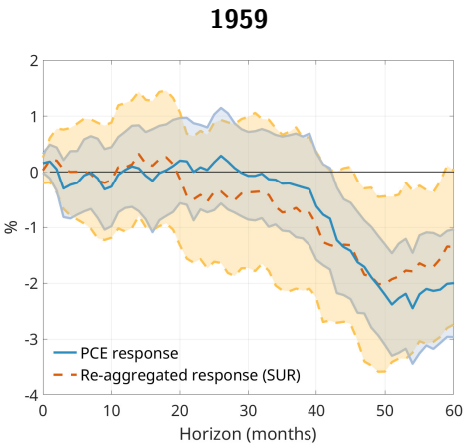




- Changes in expenditure shares have not accelerated the PCEPI response

RE-AGGREGATION FOR LEVEL 5 – CORE

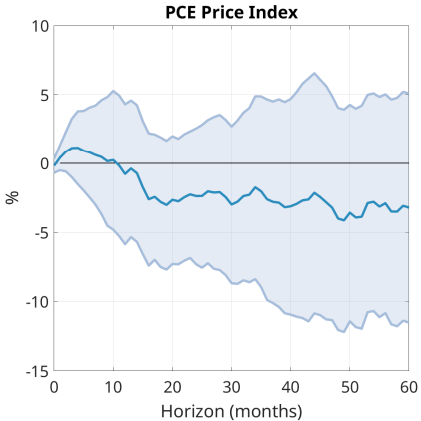
BACK

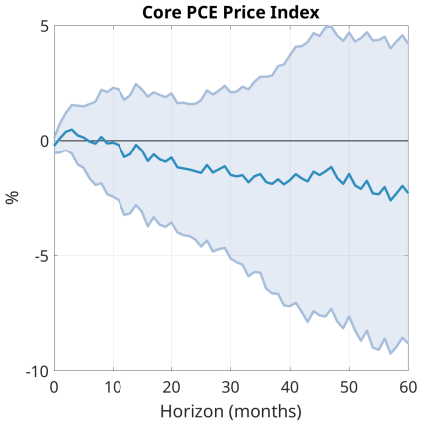


- Core PCEPI response has accelerated slightly

ARE THE EFFECTS STRONGER FOR TIGHTENING EPISODES?

BACK





- Difficult to detect asymmetric effects