Relative Price Shocks and Inflation

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[1] The views here are those of the authors alone. They do not represent the views of any part of the Federal Reserve System.

Overview

- There are large monthly relative price changes across consumption categories.
- What role do the factors driving those *relative* price changes play in the behavior of inflation in a stable monetary regime?
- Study U.S. from 1995 to 2019, multi-sector NK model.
  - overall contrib'n of relative price shocks to inflation
  - in sample application to inflation shortfall (2012-2019)
  - out of sample application to COVID (maintained assumption regime remained stable)
- Additional discussion of COVID inflation, does it seem to come from same stable regime?

Outline

1. Motivation and literature
2. Model
3. General properties of model
4. Estimated parameters
5. Properties of estimated model
6. Applications: shortfall, COVID
7. COVID inflation without a theoretical model
8. Conclusion

Motivation

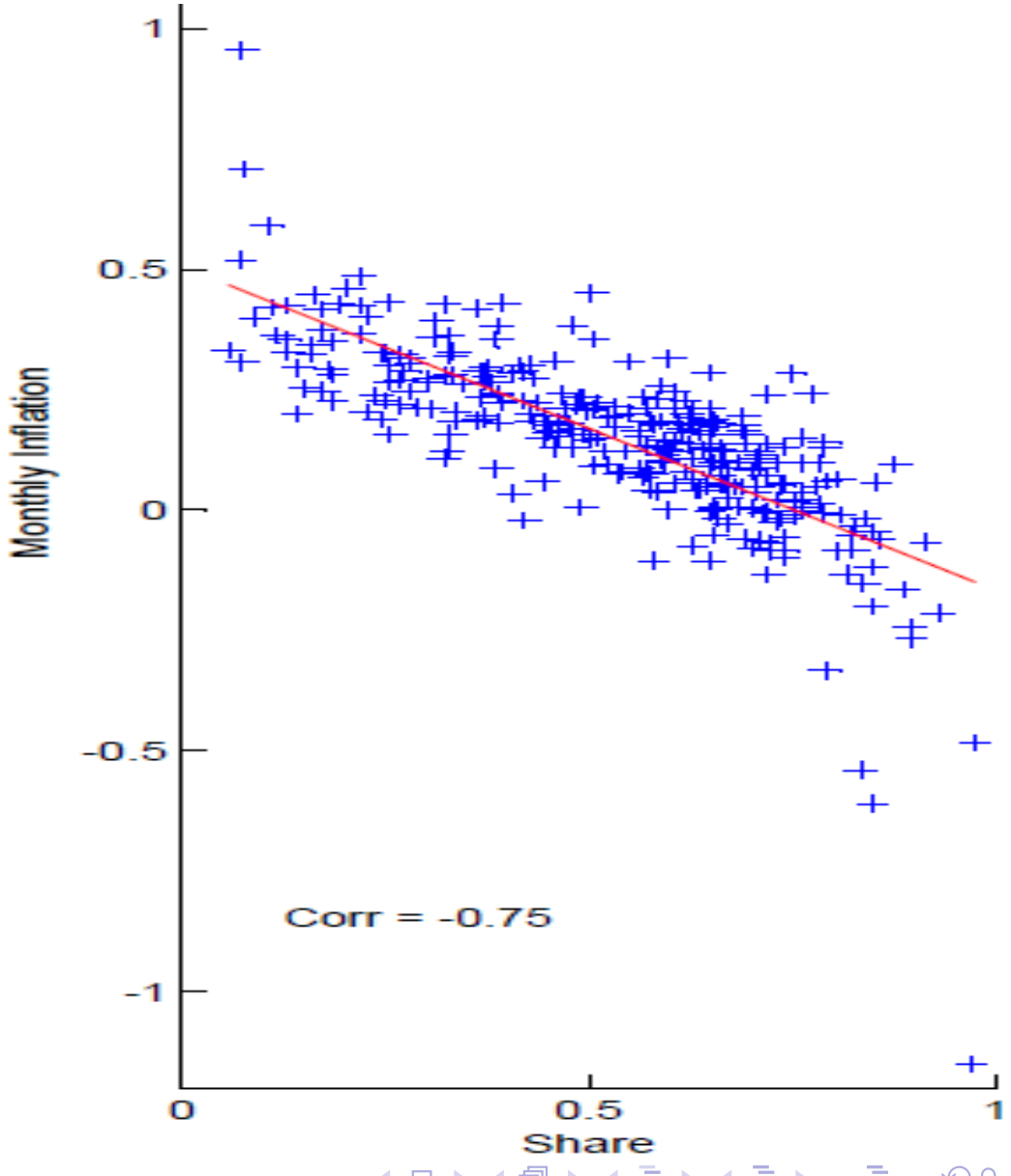
- Practical central banking question: to what extent is inflation driven by real shocks when CB is following a stable policy?
- To answer that question we need two things:
  - A model
  - Data from a stable regime
- We have a model, and arguably data from a stable regime.

Literature

- Many, many papers. A few especially relevant:
- Models where distribution of "relative price shocks" matters for inflation:
  - Ball and Mankiw (1995): fixed costs, so firms only adjust if large desired price change
  - Balke and Wynne (2000): sectoral productivity shocks interact with; flexible prices, constant money growth
  - Smets et al. (2019): emphasize input-output mechanism
- Reis and Watson (2010) factor model, argue inflation associated to a large extent with relative price changes.

More motivation

- U.S. data 1995-2019
- Monthly inflation (y-axis) closely related to monthly share of relative price increases (x-axis).
- To understand inflation, need to understand distrib'n of relative price changes (*in a stable monetary regime*).



The model in one slide

- Basic NK model, 15 consumption categories ("sectors")
  - Cobb-Douglas across sectors

$$C_t = \prod_j \xi_j^{-\xi_j} c_{j,t}^{\xi_j} \tag{1}$$

  - CES within sectors (Dixit-Stiglitz)

$$c_{j,t} = \left(\int (c_{l,j,t})^{(\theta-1)/\theta} \, dl \right)^{\theta/(\theta-1)}, \tag{2}$$

- Heterogeneity across sectors:
  - Productivity process persistence ρ_j, shock variance σ_j^2
  - Price stickiness parameter (Rotemberg), ϕ_j
- Standard Taylor-type rule
- Local analysis around target inflation rate

General properties of model (1)

Feasible to perfectly stabilize inflation

- Sectoral productivity shocks (we call them relative price shocks) mean cannot stabilize ALL prices.
- But no problem *in the model* to hit π^* every period: policy rule $\pi_t = \pi^*$.
- Intuition from flex price model: real shocks determine relative prices and monetary policy determines inflation.
- With sticky prices, no dichotomy, but monetary policy can still choose inflation (*in the model*).

General properties of model (2)

For a "typical" policy rule, relative price shocks move inflation:

- Sectoral shocks are aggregate shocks, and as such, they move the inflation rate.
- Under a perfect inflation peg $\pi_t = \pi^*$, equilibrium function for R_t involves large responses to all sectoral productivity shocks.
- In contrast, with Taylor type rule, equilibrium R_t has small responses to all sectoral shocks (*but not zero*).

Estimation

- Maximum likelihood using Kalman filter.
- Observables: sectoral price changes and fed funds rate.
- U.S. data, 1995-January 2020.
- Calibrate parameters that determine steady state.
- Linearize model around steady state with balanced growth:
  - Inflation target $\pi^* \approx 2\%$.
  - Sectoral trend prod. growth from trends in relative prices.
  - Accommodate trend in interest rate with time-varying r^*: fit quadratic time trend to r_t.

Estimated parameters (highlights)

Heterogeneity in price stickiness and shock processes

Category	Price stickiness ϕ_j	Shock σ_j
Motor vehicles and parts	7.32	0.46
Furnishings and household durables	0.19	0.39
Recreational goods	0.68	0.38
Other durable goods	0.00	0.58
Food at home	4.23	0.32
Clothing and footwear	0.52	0.55
Gasoline and other energy goods	3.67	6.14
Other nondurable goods	0.03	0.32
Housing and utilities	8.49	0.19
Health care	4.09	0.18
Transportation services	0.26	0.53
Recreation services	2.09	0.24
Food services and accommodations	111.12	1.99
Financial services and insurance	0.00	0.71
Other services	12.89	0.27

Properties of estimated model: summary

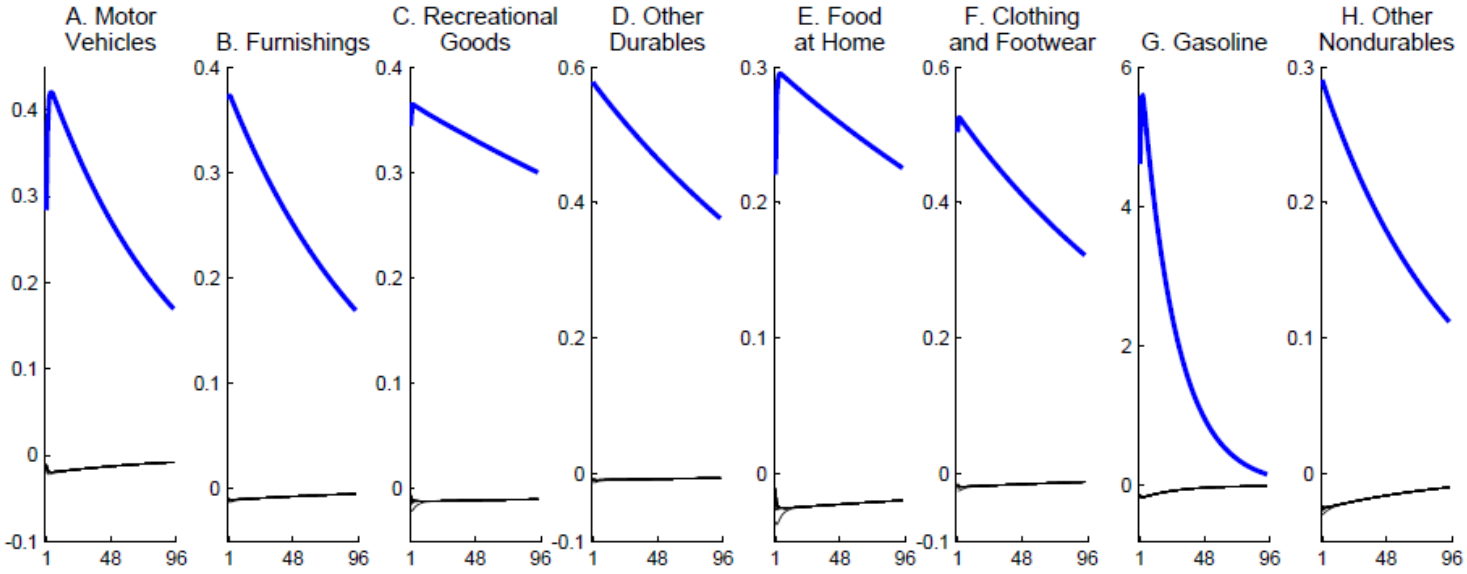
1. Fits sectoral and aggregate price change data, by construction.
2. Sectoral productivity shocks drive own relative prices, small opposite effect on other relative prices (by definition, zero effect on average relative price).
3. Sectoral productivity shocks primary driver of inflation ($\approx 75\%$), rest monetary policy (**stable regime**).
4. Model matches empirical relationship between inflation and share of relative price increases.
5. Clear heterogeneity in price stickiness, but heterogeneity in shock volatility more important for matching relationship between relative price changes and inflation.

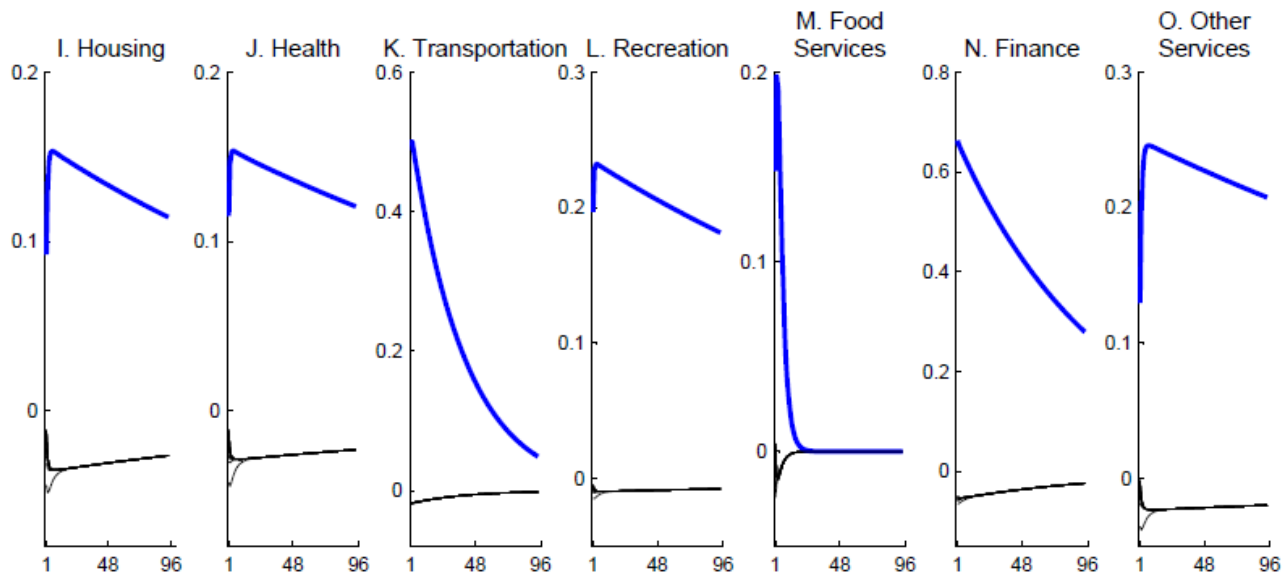
Properties of estimated model: 2nd moments

Variable	StDev		Autocorrelation	
	Data	Model	Data	Model
	(1)	(2)	(3)	(4)
Nominal interest rate	0.110	0.043	0.992	0.939
Aggregate inflation	0.187	0.252	0.387	0.139
Sectoral price changes:				
Motor vehicles and parts	0.315	0.348	0.307	0.325
Furnishings and household durables	0.377	0.432	−0.019	0.000
Recreational goods	0.355	0.415	0.026	0.047
Other durable goods	0.597	0.628	−0.170	−0.013
Food at home	0.263	0.307	0.266	0.228
Clothing and footwear	0.517	0.566	0.016	0.039
Gasoline and other energy goods	4.986	4.828	0.349	0.211
Other nondurable goods	0.303	0.382	−0.140	−0.024
Housing and utilities	0.140	0.197	0.338	0.324
Health care	0.148	0.224	0.116	0.207
Transportation services	0.511	0.558	−0.045	0.005
Recreation services	0.208	0.273	0.097	0.127
Food services and accommodations	0.169	0.211	−0.056	0.288
Financial services and insurance	0.722	0.762	−0.236	−0.012
Other services	0.171	0.221	0.356	0.410

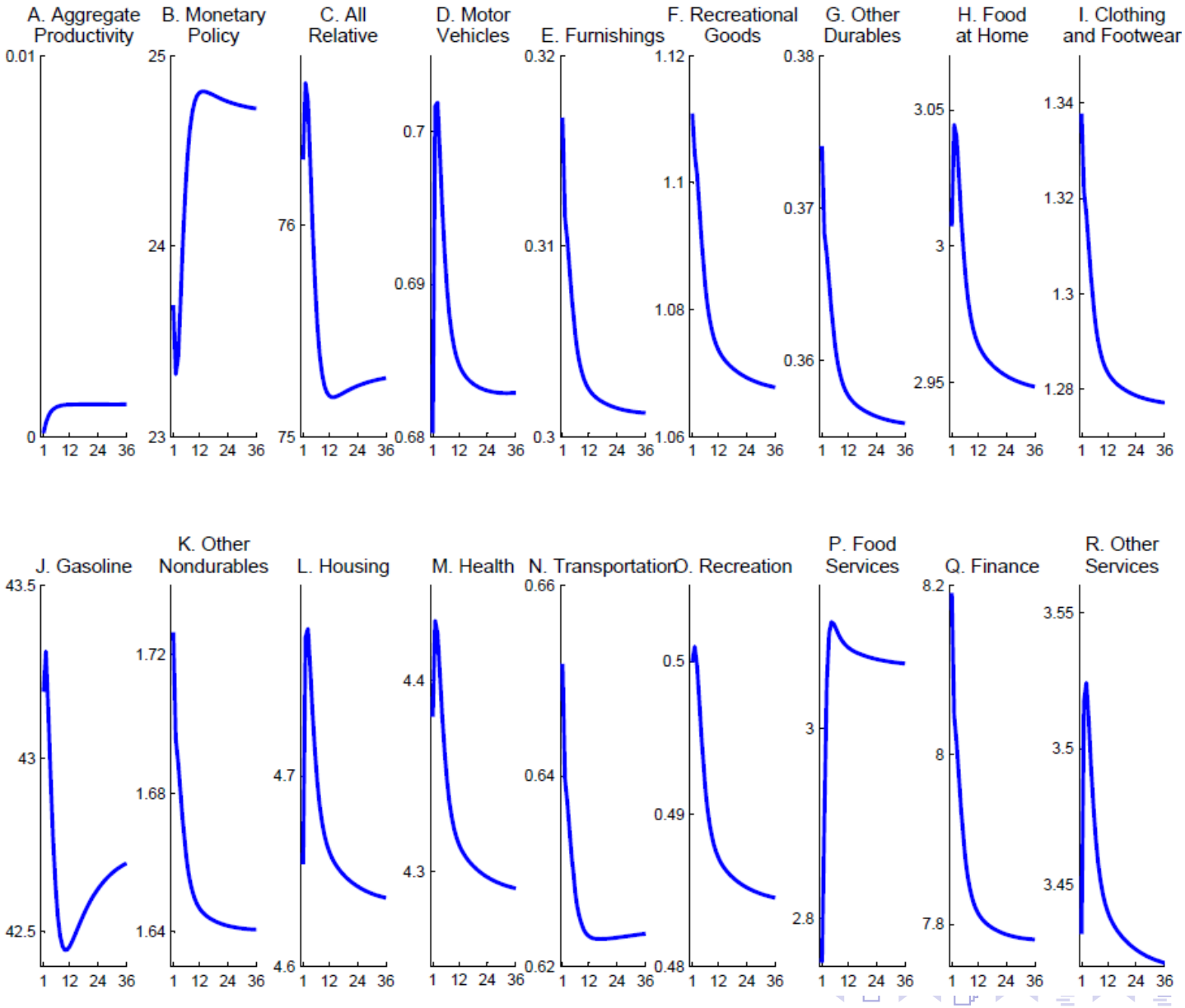
IRFs of all relative prices to 1-stdev sectoral shocks

- Large own response (blue)
- Small other responses (black)





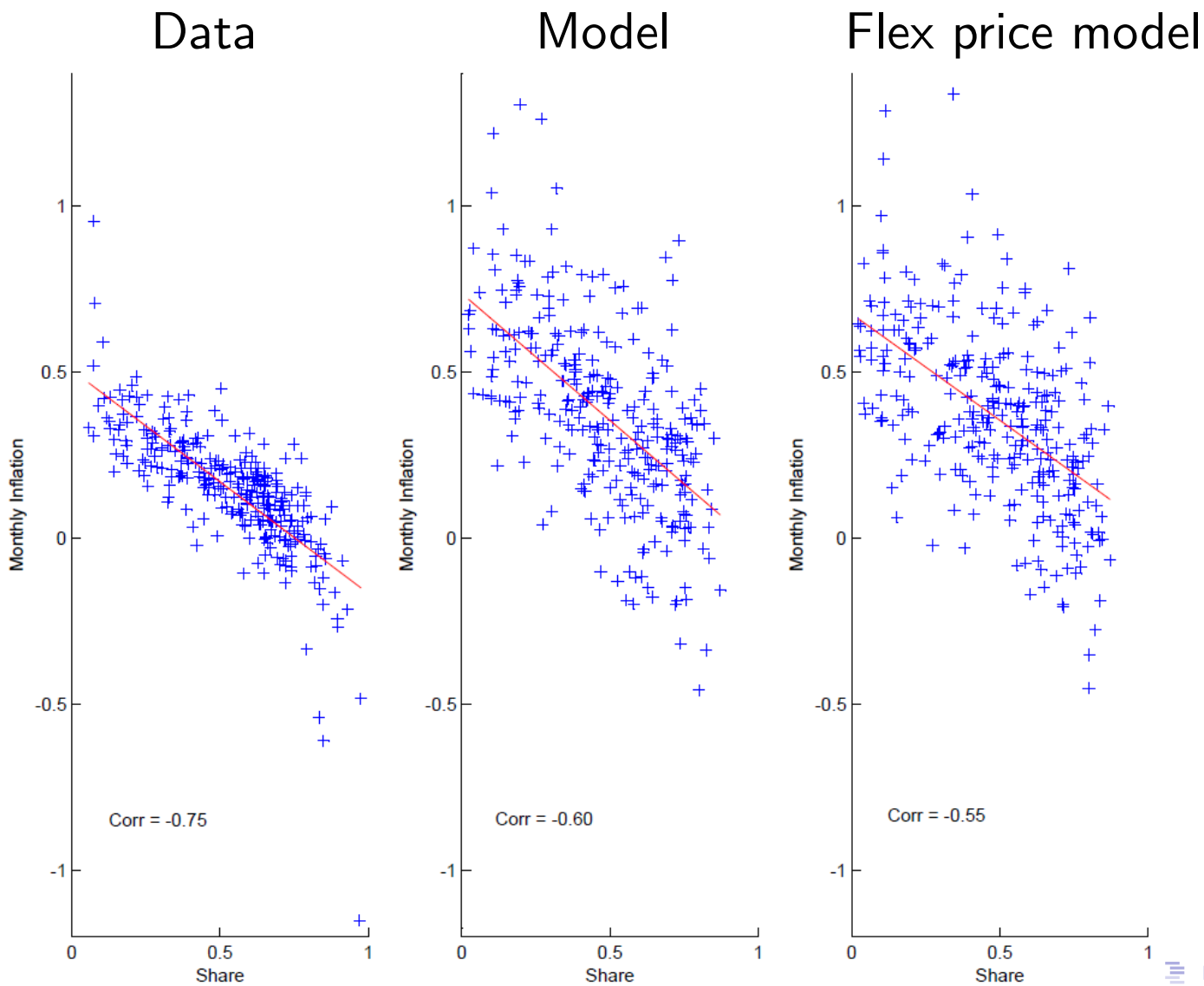
Variance decomposition of inflation (scales differ)



Properties of estimated model: variance decompositions

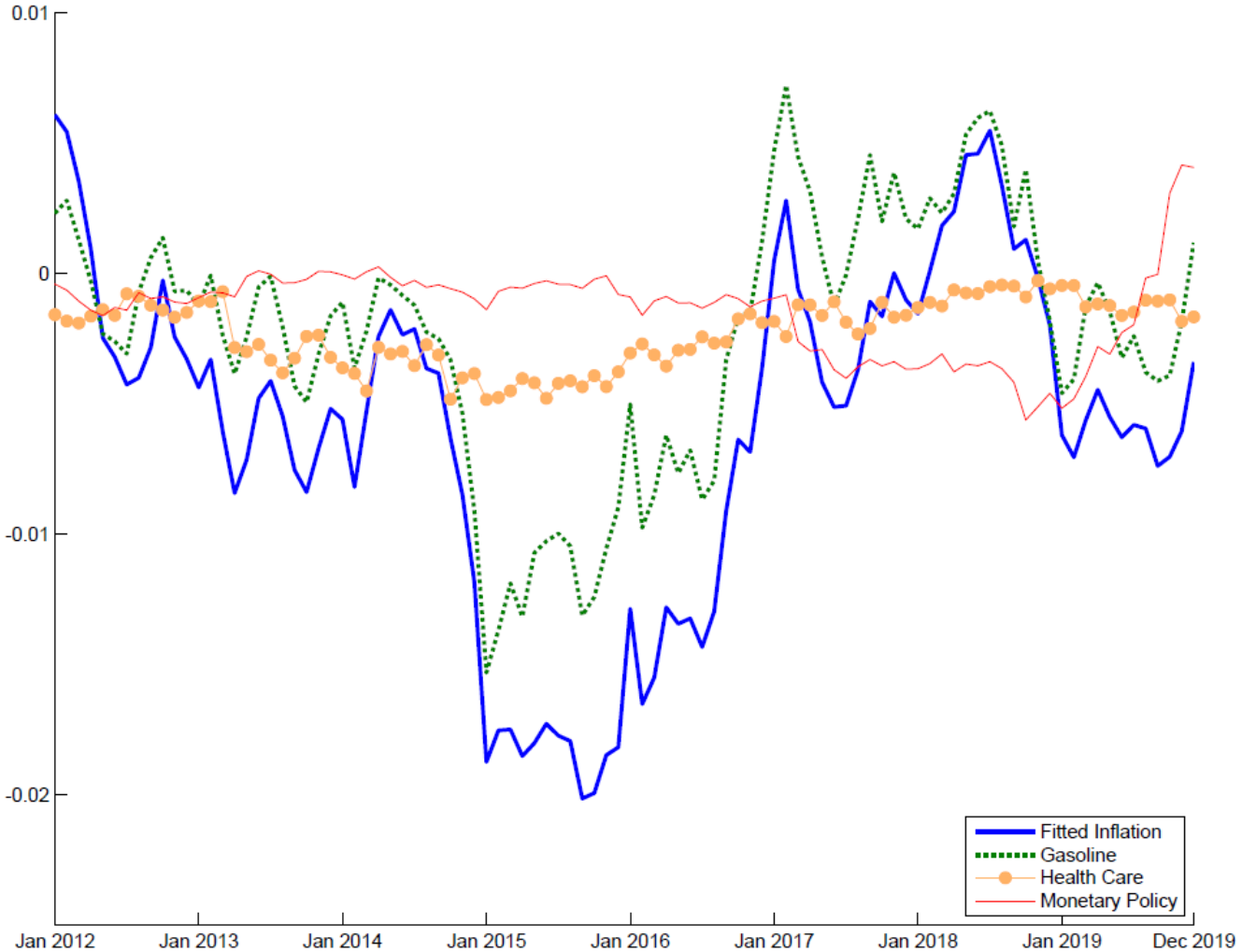
	Benchmark		Flexible-Price	
Variable	Own Shock	Mon. Policy	Own Shock	Mon. Policy
Motor vehicles and parts	86.48	9.99	81.68	15.47
Furnishings and household durables	78.46	15.44	86.02	11.87
Recreational goods	79.42	14.98	83.97	13.43
Other durable goods	89.22	7.71	93.40	5.54
Food at home	77.91	16.67	73.18	22.58
Clothing and footwear	88.41	8.37	91.77	6.91
Gasoline and other energy goods	99.90	0.07	99.90	0.08
Other nondurable goods	71.31	20.54	79.14	17.45
Housing and utilities	62.43	28.99	52.78	41.52
Health care	58.41	31.88	53.19	40.68
Transportation services	87.26	9.14	91.80	6.96
Recreation services	62.77	27.27	64.39	29.91
Food services and accommodations	94.81	3.06	55.79	36.98
Financial services and insurance	92.74	5.24	95.49	3.78
Other services	77.02	17.81	57.72	35.96

Properties of estimated model: inflation and the share of relative price increases



U.S. inflation undershoot, 2012-2019

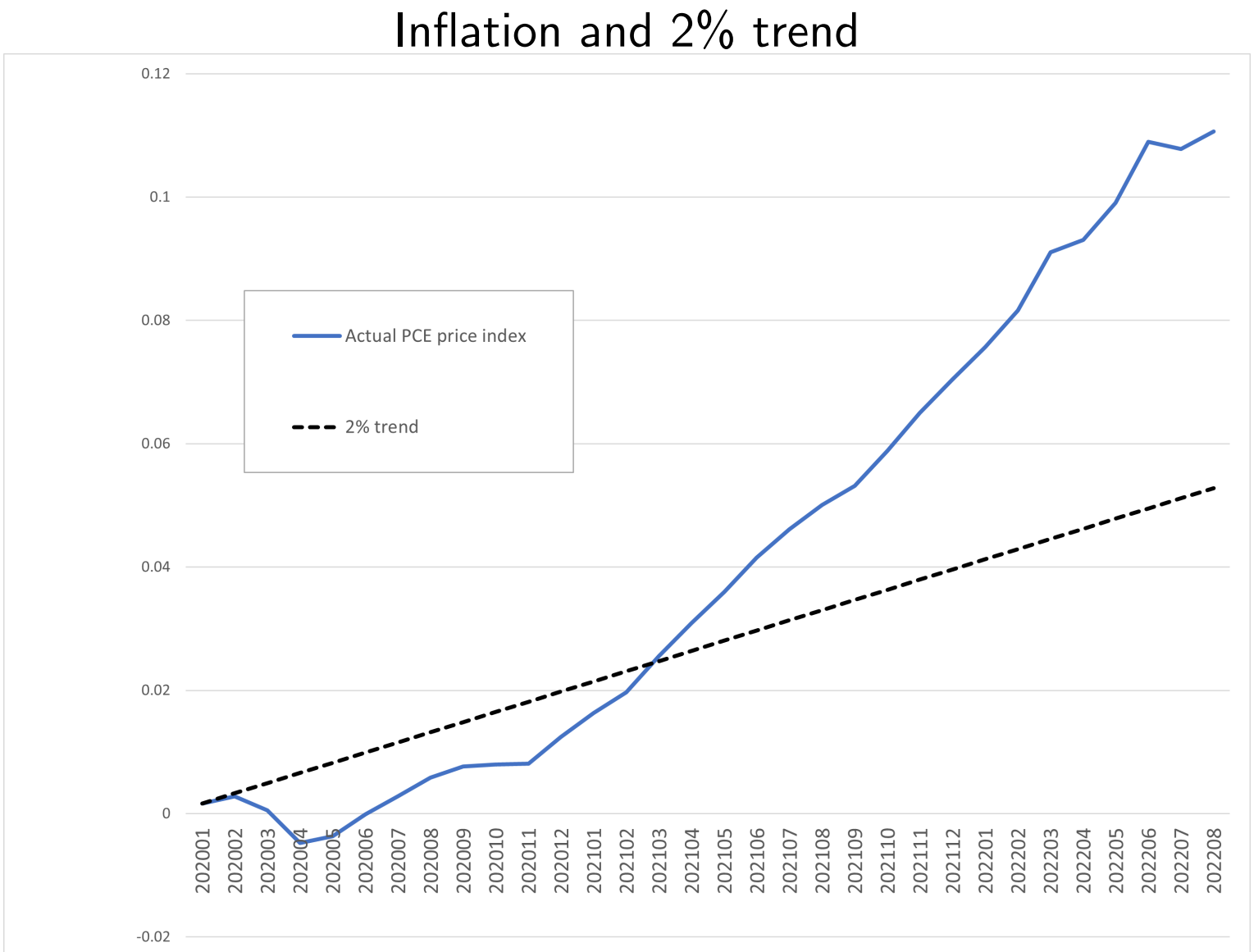
Gasoline and health care shocks primary drivers



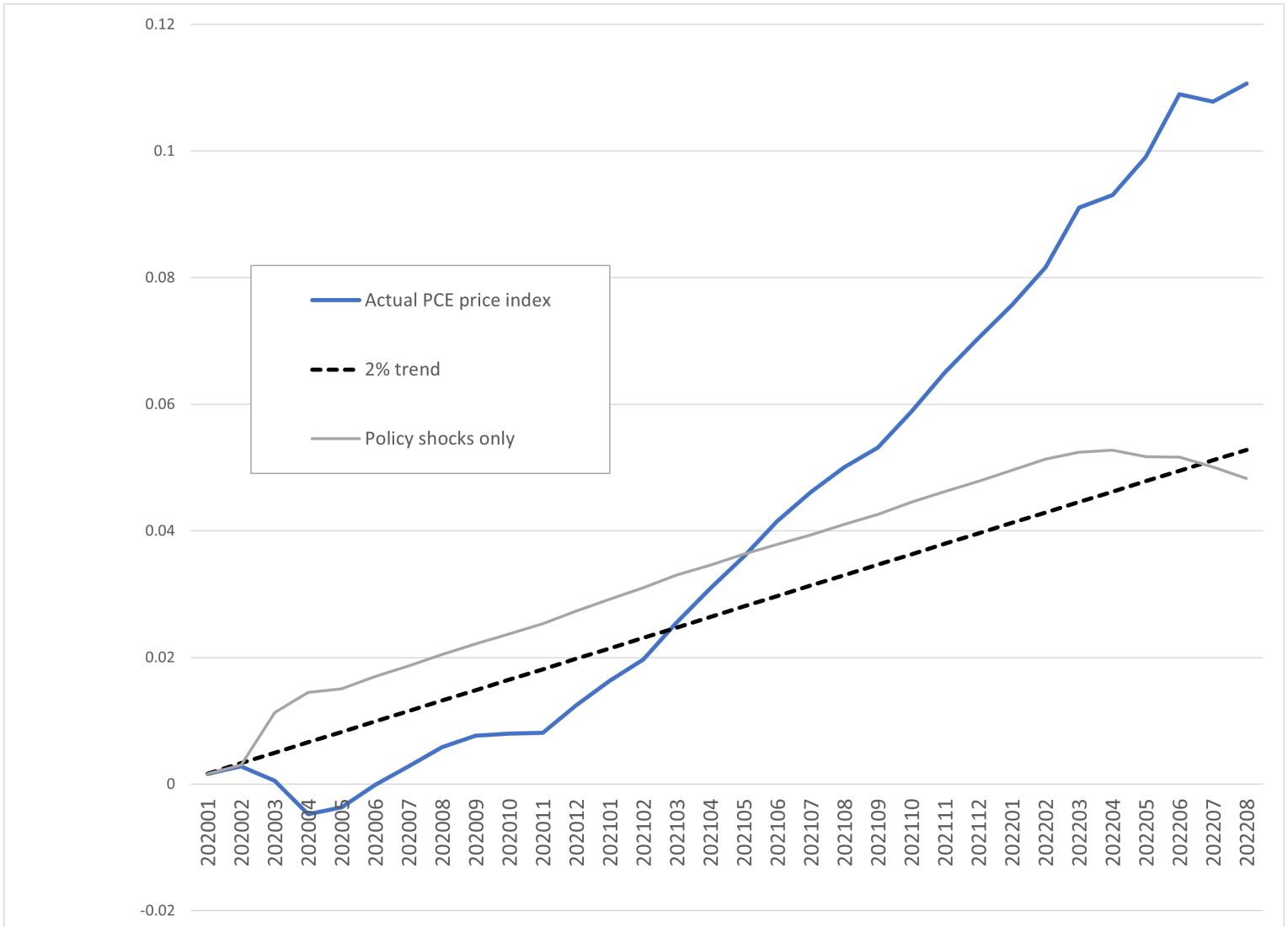
COVID inflation (out of sample)

- Decompose COVID inflation into contrib'ns of various shocks
- Strong caveats!
  - COVID is not in the sample.
  - We filter inflation and price change data under assumption the estimated parameters still apply: inflation anchored at target and only effect of policy is through shocks that are expected to fade.
  - The estimated model has sectoral supply shocks, no sectoral demand shocks.
  - Etc.

COVID inflation



COVID inflation (out of sample)



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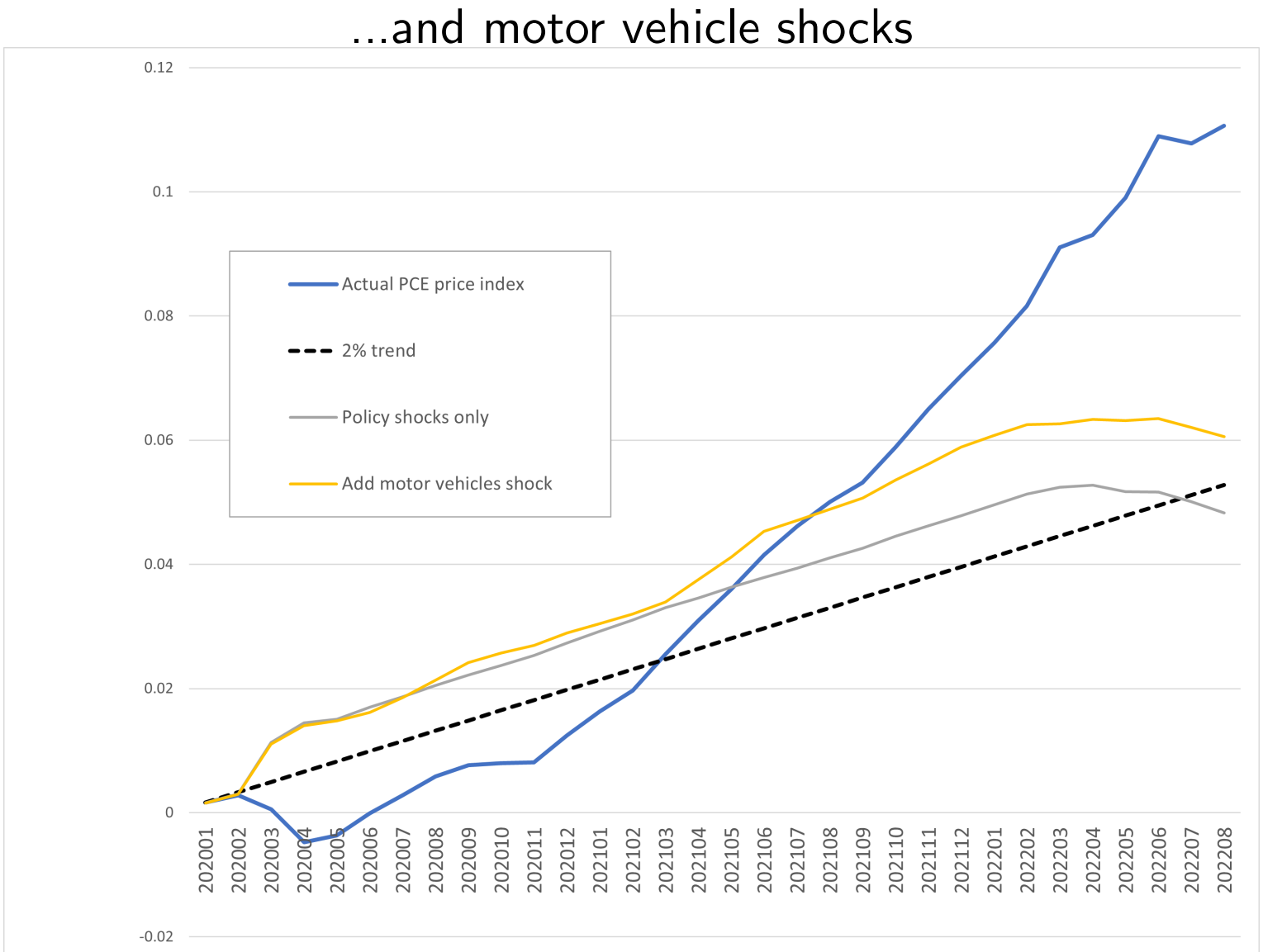
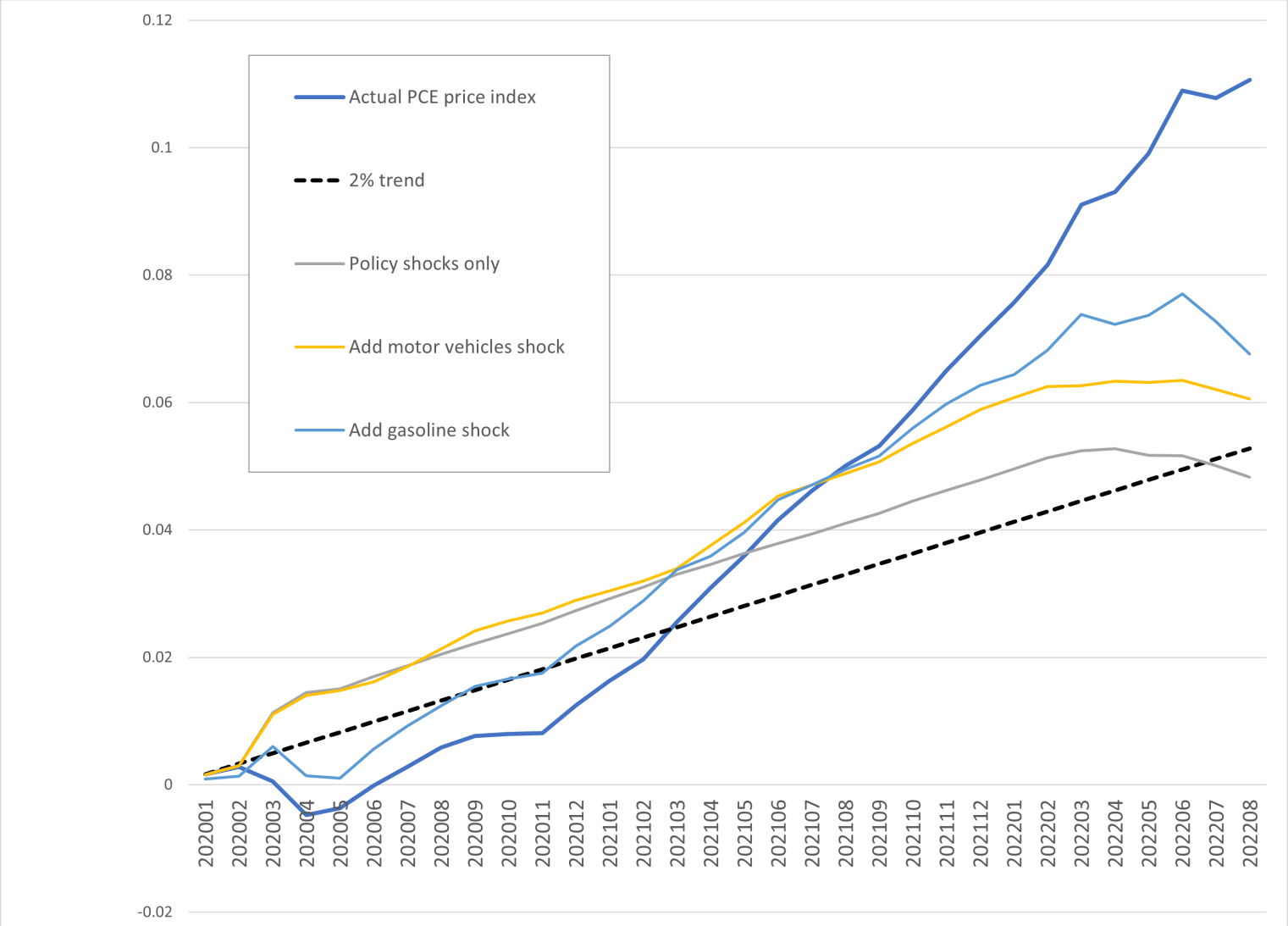


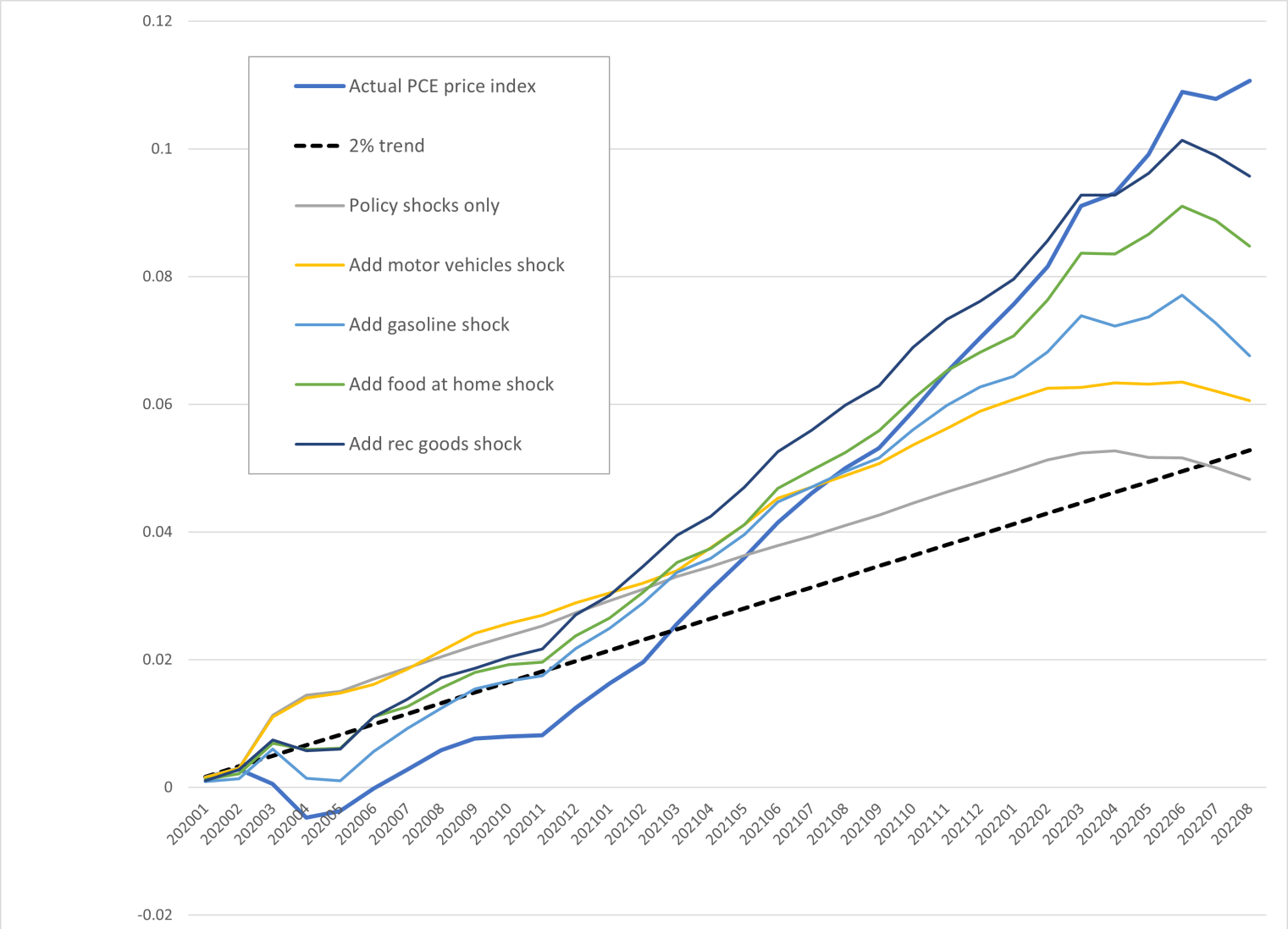
COVID inflation (out of sample)

...and gas and energy shocks



COVID inflation (out of sample)

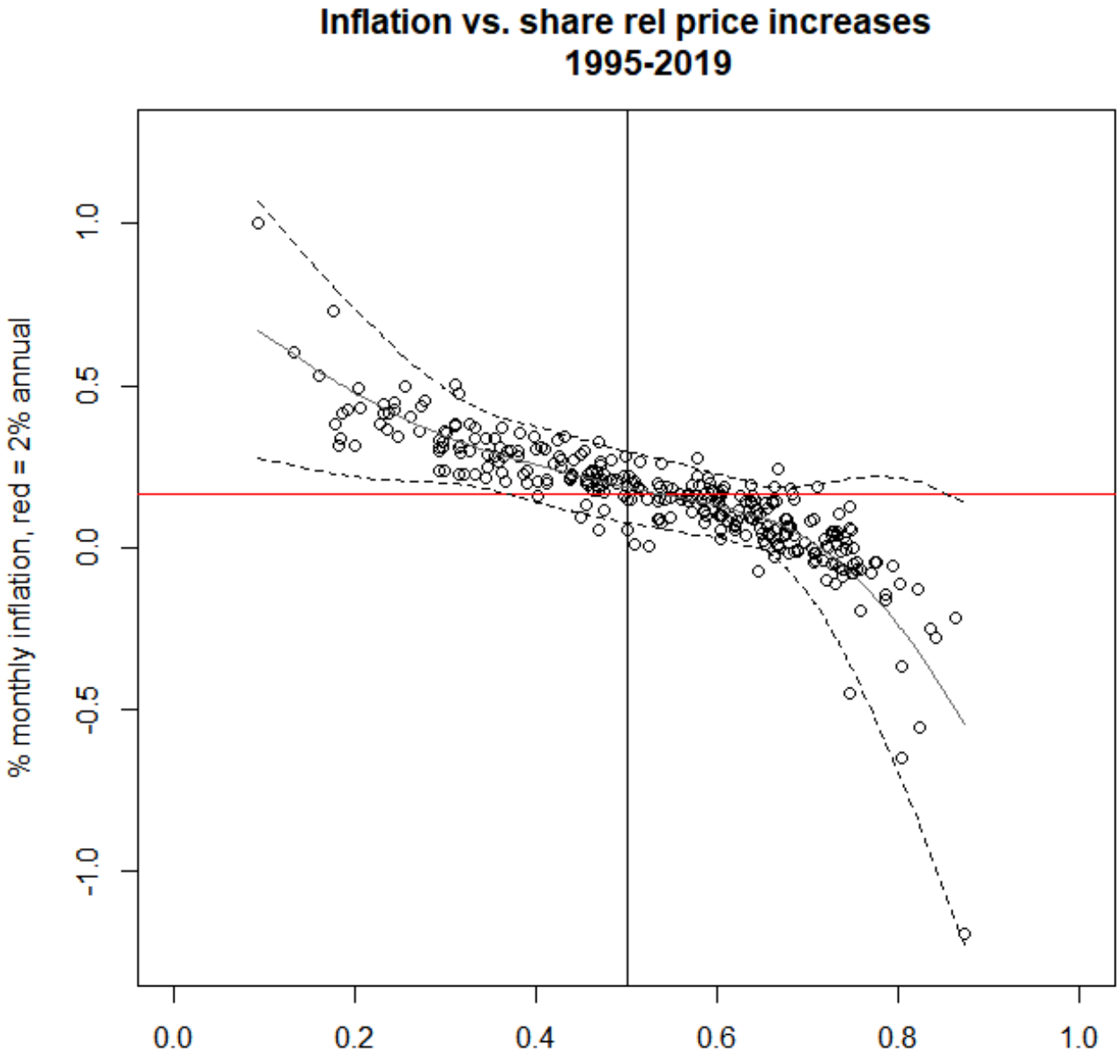
...and more



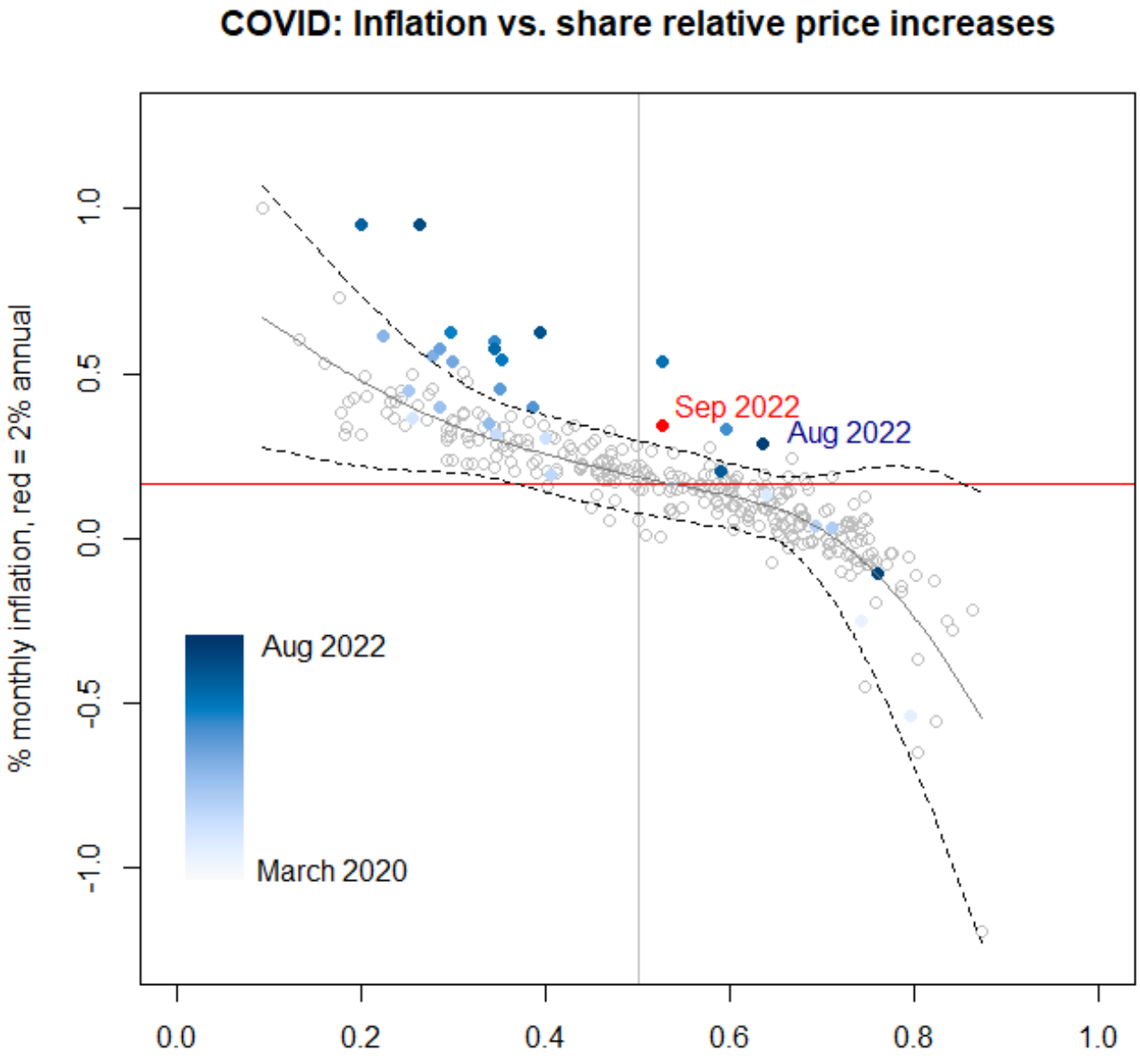
COVID inflation without the model

- Model-based decomposition of COVID inflation can't tell us whether inflation remains anchored.
- Can get *some* insight from recent behavior of inflation and share of relative price increases.
- Recall earlier picture: high inflation corresponded to low share of relative price increases.
- Will provide version of that picture using 208 categories, then add COVID data.
- Recent behavior of inflation seems to represent upward shift relative to prior relationship, but that could represent unusual shocks within same regime.

Pre-COVID inflation & share of relative price increases



COVID inflation & share of relative price increases



Conclusion

- Within a stable monetary regime, "relative price shocks" can move around the inflation rate.
- We quantify this effect in an estimated 15-sector NK model; find relative price shocks account for majority of volatility in U.S. monthly inflation, 1995-2019.
- Use the framework to decompose inflation shortfall (in sample) and COVID inflation (out of sample)
- To do list (partial)
  - Add demand shocks (sectoral and aggregate)
  - Allow for lagged cross correlation between sectoral shocks