The Ever-Changing Challenges to Price Stability

Andrea De Polis[†] Leonardo Melosi[‡⋆] Ivan Petrella[†⋆]

Forecasting @ Risk, ECB, June 13, 2023

[†]Warwick Business School

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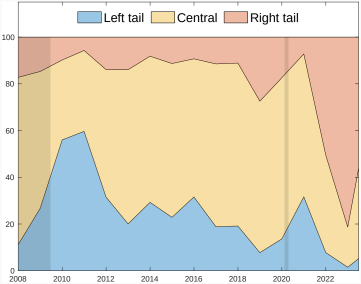
[⋆]CEPR

Introduction

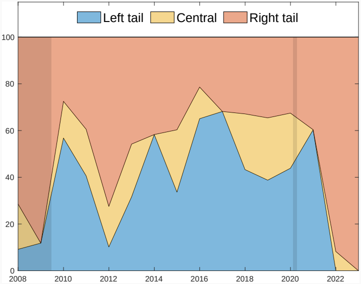
Motivation

- Economic agents are becoming increasingly concerned with swift changes in the balance of risks of inflation.

Professional Forecasters



Consumers



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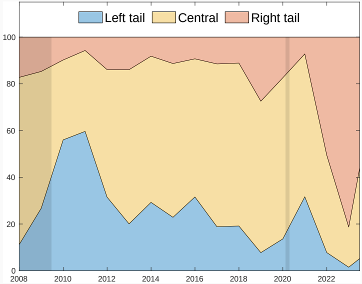

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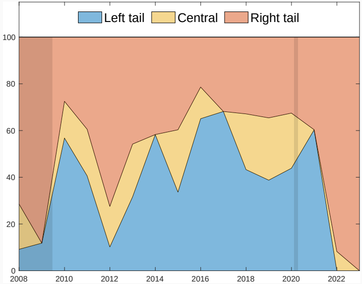

- Nonetheless, the economic literature has primarily focused on the long-run mean, persistence, and volatility of inflation over time.

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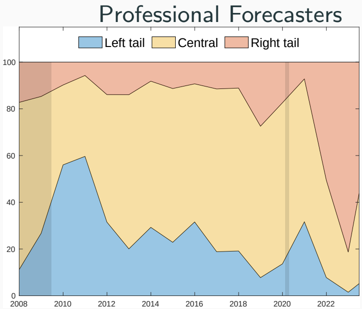
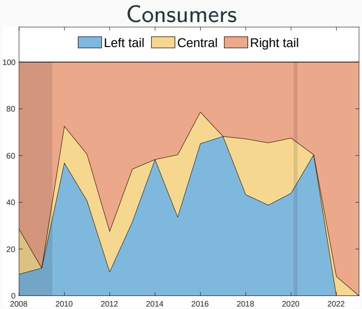
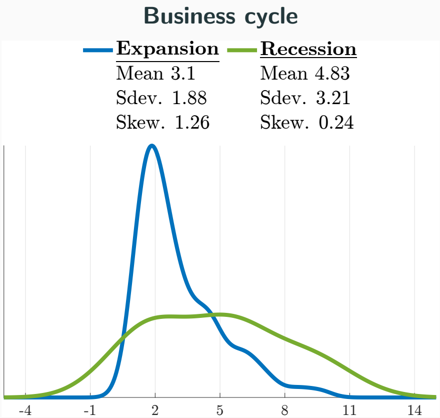




- Nonetheless, the economic literature has primarily focused on the long-run mean, persistence, and volatility of inflation over time.
- Much less is known about the risks to inflation, their dynamics and what predicts them.

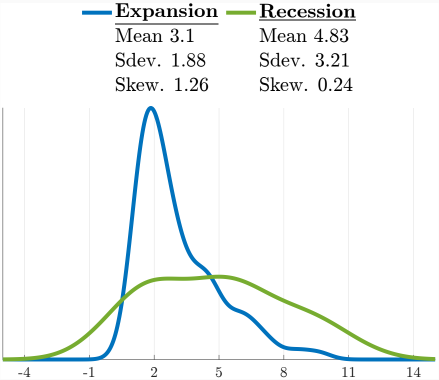
Inflation risks varies at different frequencies



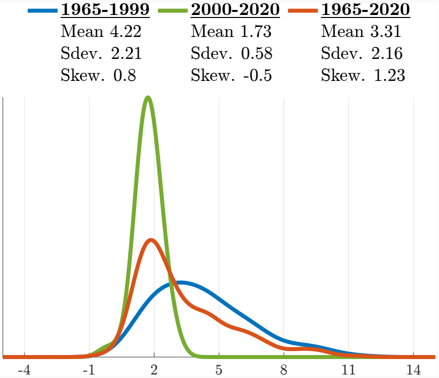
- Inflation properties move along the business cycle...

Inflation risks varies at different frequencies

Business cycle



Long-run



- Inflation properties move along the business cycle...
- ... as well as over longer periods.

What we do and **what we find**

We measure the evolution over time of inflation risks via a flexible time-varying parameters model.

↪ Asymmetries vary substantially over time.

We predict time-variation in inflation moments with exogenous predictors for the short- and the long-run.

↪ Inflation risk follow regime-like path, related to fiscal and monetary policy stance.

We allow for non-linearities in the elasticity of expected inflation to changes in the predictors.

↪ Phillips curve-type relation seem not stable and depends on prevailing risk regime.

Three key takeaways

1 - Monetary and fiscal regimes are important to understand long-run inflation risk.

2 - There is no *one-size-fit-all* policy framework to stabilize inflation.

3 - Make-up strategies need to account for asymmetry in the predictive distributions of inflation risks.

Model

Model: specification

$$\pi_t = \mu_t + \varepsilon_t \quad \varepsilon_t \sim skt_\nu(0, \sigma_t, \rho_t)$$

$\hookrightarrow$ μ_t: location

$\hookrightarrow$ σ_t: scale

$\hookrightarrow$ ρ_t: shape

$$\ell_t(\pi_t|\theta, \Pi_{t-1}) = c(\eta) - \frac{1}{2}\log\sigma_t^2 - \frac{1+\eta}{2\eta}\log\left[1 + \frac{\eta\varepsilon_t^2}{(1+sgn(\varepsilon_t)\rho_t)^2\sigma_t^2}\right]$$

where $sgn(x)$ is the sign of x, and $\nu = 1/\eta$ are the dof, as in (Delle Monache et al. 2021).

Time-varying parameters

For $f_t = (\mu_t, \gamma_t, \delta_t)'$, where $\gamma_t = \ln \sigma_t$ and $\delta_t = \operatorname{atanh} \rho_t$:

$$f_{t+1} = f_t + \bar{\beta}\bar{X}_t + \tilde{\beta}\tilde{X}_t + \alpha s_t,$$

where $s_t = \mathscr{S}_{t-1}\nabla_t$, $\nabla_t = \frac{\partial \ell_t}{\partial f_t}$, and $\mathscr{S}_{t-1} \propto \mathscr{I}_{t-1}^{-1} = \mathbb{E}_{t-1}\left[\frac{\partial \ell_t}{\partial f_t \partial f_t'}\right]^{-1}$.

s_t maps ε_t into an appropriate update for f_t (Creal et al. 2013, Harvey 2013).

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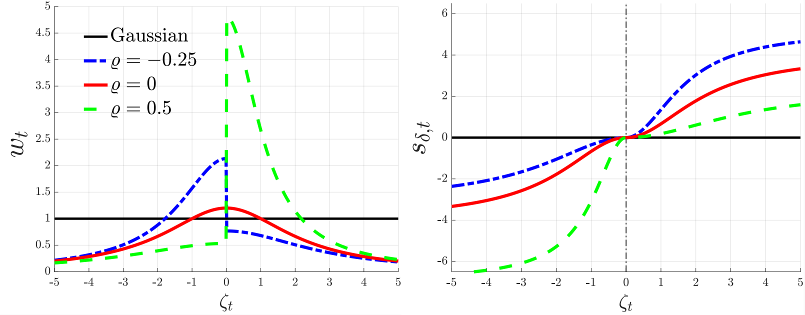
Outlier discounting **Asymmetry updating**



Model: Non-linearity in mean

Expected inflation is a non-linear function of σ and ρ

$$\mathbb{E}[\pi_t] = \mu_t + g(\eta)\sigma_t\rho_t.$$

The model turns a linear dependence between unobserved parameters and predictors into a non-linear relation with the moments of the predictive density of inflation.

▸ Elasticity

Predictors

Predictors

We investigate non-linear relations of predictors with inflation dynamics.

Short-run	
- MPS, 3m - 2Y spread	
- UNG, Unemployment gap	
- ΔULC, Unit labor cost	
- ICI, Commodity prices (with oil)	
- RER, Real exchange rate	

*Policy variables

Predictors

We investigate non-linear relations of predictors with inflation dynamics.

Short-run	Long-run
- MPS, 3m - 2Y spread	- ΔM3N, Money growth
- UNG, Unemployment gap	- FSD, Fiscal stance
- ΔULC, Unit labor cost (cycle)	- ΔULC, Unit labor cost (trend)
- ICI, Commodity prices (with oil)	- LRR, Long-run real rate
- RER, Real exchange rate	

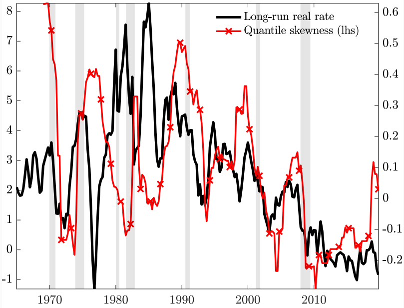
*Policy variables

- We use Müller & Watson (2018) filter to decompose some predictors into secular trends ($\geq$ 10y freq.) and residual cycles.

Long-run covariability: the real rate

We estimate model-free rolling measures of skewness and relate them to the long-run real rate

All frequencies

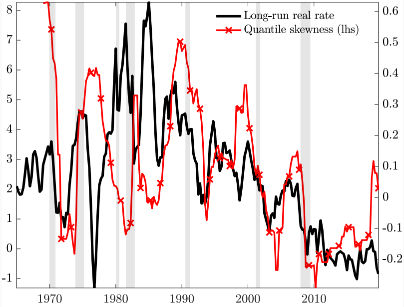


- Covariability appears to be stronger in the second part of the sample.

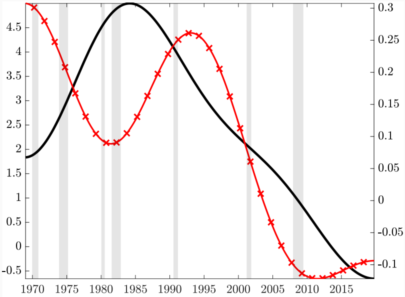
Long-run covariability: the real rate

We estimate model-free rolling measures of skewness and relate them to the long-run real rate and to its low-frequency component

All frequencies



Low-frequency



- Covariability appears to be stronger in the second part of the sample.
- Trend component anticipate low-frequency changes in skewness.

Covariability in the long-run

We select variables generally associated with different inflation regimes

	Location		Dispersion		Asymmetry	
	Sample	Quantile	Sample	Quantile	Sample	Quantile
	Low frequency					
ΔULC	**0.445** [0.027,0.719]	**0.448** [0.028,0.721]	**0.538** [0.184,0.813]	0.213 [−0.158,0.539]	0.273 [−0.103,0.593]	0.028 [−0.379,0.443]
FSD	−0.133 [−0.511,0.210]	−0.157 [−0.524,0.209]	−0.200 [−0.529,0.158]	−0.030 [−0.413,0.337]	**0.454** [0.082,0.714]	**0.503** [0.115,0.782]
ΔM3N	0.150 [−0.212,0.503]	0.161 [−0.209,0.524]	0.213 [−0.150,0.533]	−0.022 [−0.413,0.365]	−0.031 [−0.429,0.334]	**−0.412** [−0.669,−0.001]
LRR	**0.825** [0.539,0.931]	**0.813** [0.513,0.924]	**0.651** [0.301,0.866]	**0.447** [0.013,0.724]	**0.461** [0.036,0.772]	0.273 [−0.102,0.596]

Predictors show significant correlation with conditional skewness.

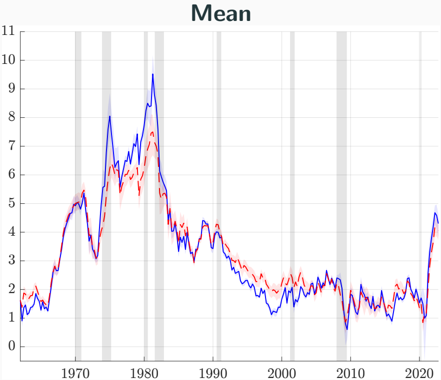
Results

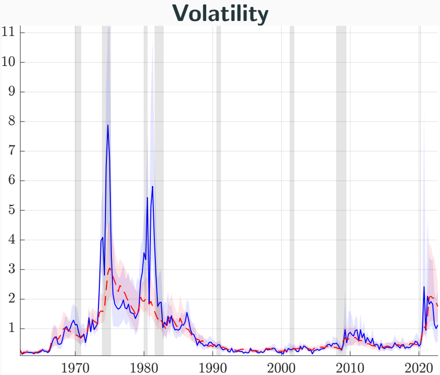
Estimation

- The model is estimated on quarterly data from 1965Q1 to 2022Q4.
- We use Bayesian techniques to estimates the model.
- Conservative views on moments time-variation.
- Priors on predictor loadings are set in the spirit of the Horse-Shoe prior to avoid overfitting.
- We devise an efficient adaptive Random-Walk Metropolis-Hastings algorithm to obtain posterior distributions.

▸ Algorithm

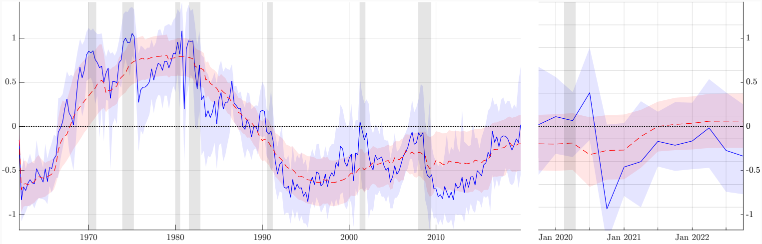
Time-varying moments: mean and volatility





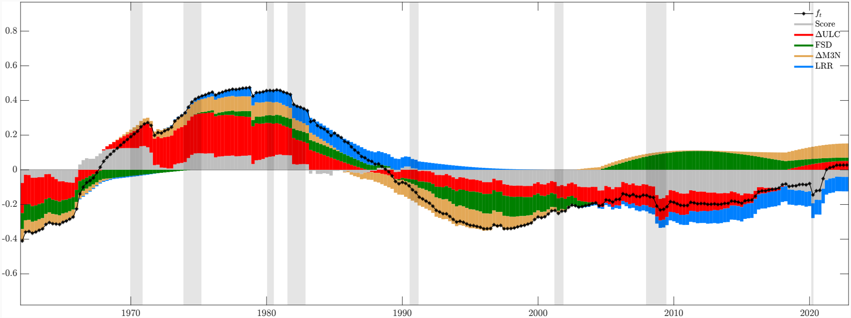
- Mean inflation floated well above its long-run trend starting from the '70s until the mid-80s;
- Volatility shows a clear reduction in the mid-80s, with a smooth trend picking up in the last part of the sample.

Time-varying moments: skewness



- Time-varying skewness peaks in the '70s and slowly reduces by the turn of the century;
- Long-run trend signals clear inversion in Inflation's risk outlook.

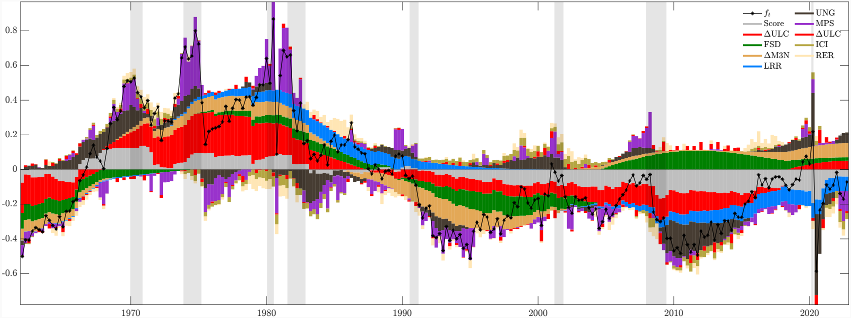
What predicts long-run inflation risk?



- Monetary-fiscal mix merges as a critical predictor of long-run inflation risks.
- Low interest rates lead to negative inflation risks, consistently with the deflationary bias due to the ZLB risk.

Location and scale

What predicts inflation risk?



- Phillips curve-type effects shows up in inflation skewness.
- The recent monetary tightening seems be the main predictor on the negative short-run skew.

▸ Location and scale

Non-linear, time-varying Phillips Curve

$$\frac{\partial E_t\left(\pi_{t+1}\right)}{\partial x_t} = \beta_{\mu x} + g\left(\eta\right)\left[\rho_{t+1}\frac{\partial \sigma_{t+1}}{\partial \gamma_{t+1}}\beta_{\gamma x} + \sigma_{t+1}\frac{\partial \rho_{t+1}}{\partial \delta_{t+1}}\beta_{\delta x}\right]$$

Expected value

Non-linear, time-varying Phillips Curve

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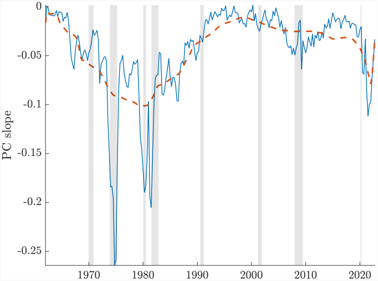
Time series PC



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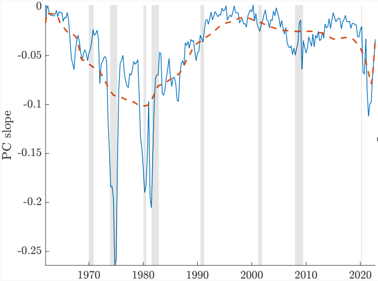
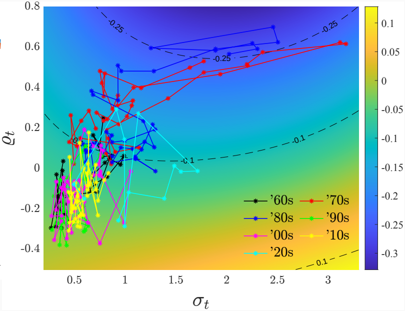


Non-linear PC



- The PC *flattens* in correspondence of periods of low risk.
- The PC relation might not be good guidance for policy makers.

Counterfactual balances of risks

$$BoR = \int_{-\infty}^{\pi^*} (\pi^* - \pi_{t+1})\, dF_\pi + \int_{\pi^*}^{\infty} (\pi_{t+1} - \pi^*)\, dF_\pi$$

$$\tilde{BoR} = \int_{-\infty}^{\pi^*} \left(\pi^* - \pi_{t+1} | X_t^{(j)}\right) dF_\pi + \int_{\pi^*}^{\infty} \left(\pi_{t+1} - \pi^* | X_t^{(j)}\right) dF_\pi$$

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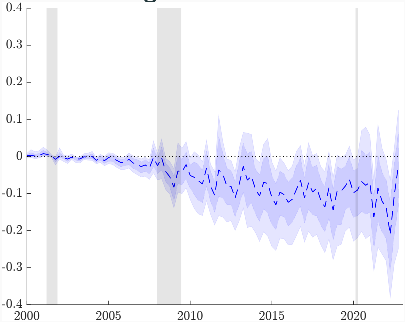
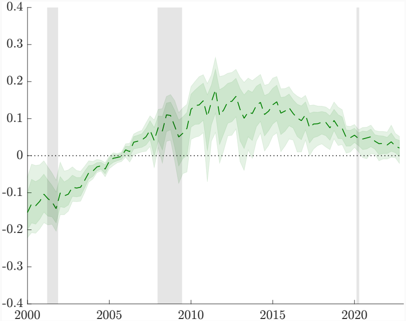
Long-run real rate



Fiscal



- The ZLB environment contributed downside risks.
- Looser fiscal stance increased risk on the upside post GFC.

Asymmetric risk & optimal policy

Why does it matter?

Consider the quadratic loss function

$$L = \mathbb{E}_t \left(\pi_{t+1} - \pi^*\right)^2$$

Expectations are formed via a generic linear learning rule

$$f_\mu\left(\mu_{t|t-1}, \varepsilon_t\right) = \mu_{t|t-1} + a_\mu \varepsilon_t, \quad \varepsilon_t \sim F_\pi.$$

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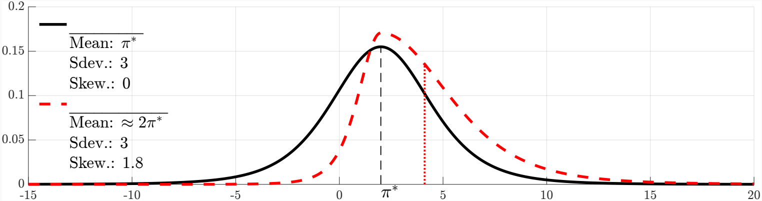
- for F_π asymmetric, $\mathbb{E}_t \pi_{t+1} = \mu_{t+1|t}$ won't solve the problem.



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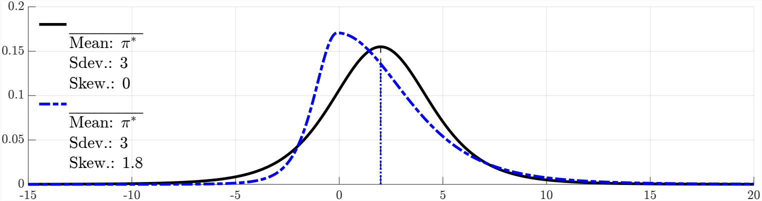
- for F_π asymmetric, $\mathbb{E}_t \pi_{t+1} = \mu_{t+1|t} + \varphi(\cdot)$ will do!



Higher moments affect the optimal policy actions, and the Central Bank optimal inflation surprise needs to offset $\varphi(\cdot)$.

Conclusions

Conclusions

We explain and quantify the policy relevance of *skewness* for inflation risks.

- Asymmetries vary substantially over time.

- Monetary and fiscal regimes are key to understand inflation risk.
  ↪ Tighter fiscal and monetary policies lifted upward pressures on prices, generating downside risks.
  ↪ ZLB spells force a downward bias to inflation, offsetting positive effects of the (large) primary deficits of the 2000s.

- Evidence of non-linear, time-varying Phillips curve.
  - The slope responds to the correlation between volatility and asymmetry.
- In an average inflation targeting framework, asymmetric inflation outlook call for the policy makers to over-/under-shoot the target.

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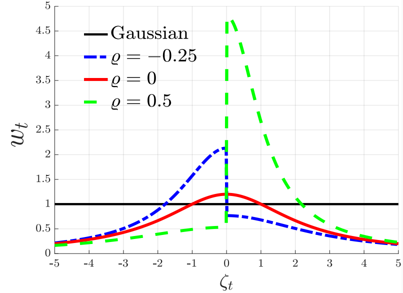
Appendix

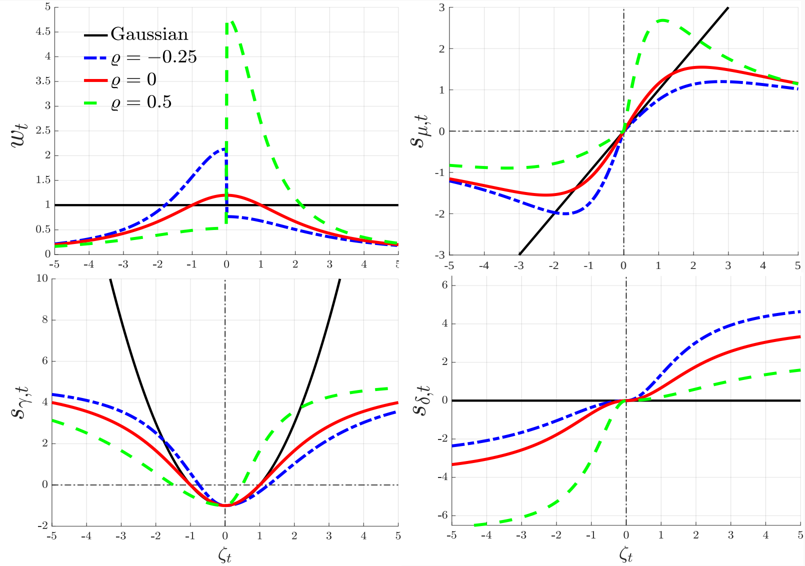
Score update: Outlier discounting

w is common to the score of each parameter, ζ=scaled prediction error.



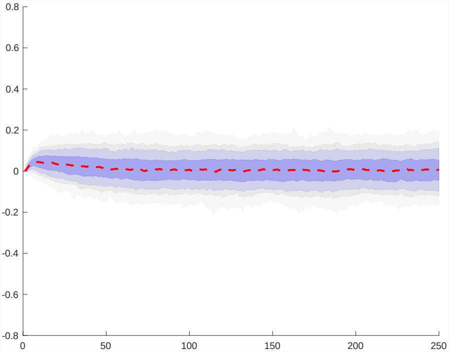
Score update: information processing

w is common to the score of each parameter, ζ=scaled prediction error.



Simulation Exercise

Would the model find any skewness when there is none in the data?



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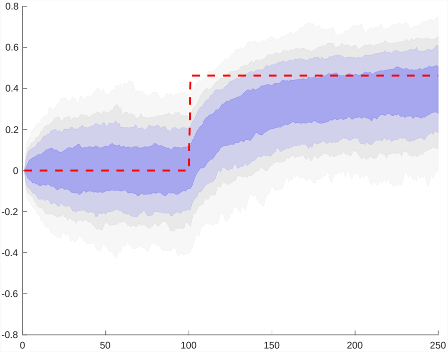
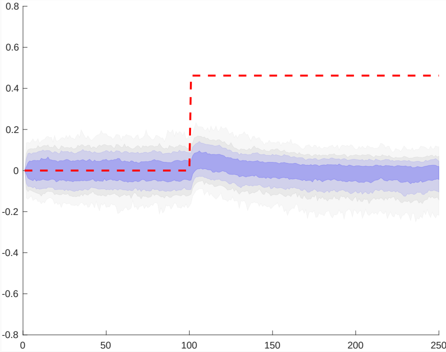
Simulation Exercise

How does the model handle sudden structural breaks?

Long-run



Short-run



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Adaptive Metropolis-Hastings

Given the vector of static parameters θ:

MH steps

Draw:	$\theta^* = \theta^{j-1} + \varepsilon,\ \varepsilon \sim \mathcal{N}(0, \Sigma_H)$
Accept:	$\theta^j = \theta^*$ with probability $p = \min\left[1, \frac{e^{\ell(\theta^j)}}{e^{\ell(\theta^{j-1})}}\right]$

Adaptive steps

Rescale:	$\sigma_s = \sigma_s r(\tilde{\alpha}^s)$, every s draws
Reestimate:	$\Sigma_H = \frac{\tilde{K}}{\sqrt{H-1}}$, every U draws

where $r(\tilde{\alpha}^s)$ is an arbitrary function of the local acceptance rate $\tilde{\alpha}^s$ to target a 30% acceptance rate. We set $s = 100$, $U = 750$ and $H = 1000$.

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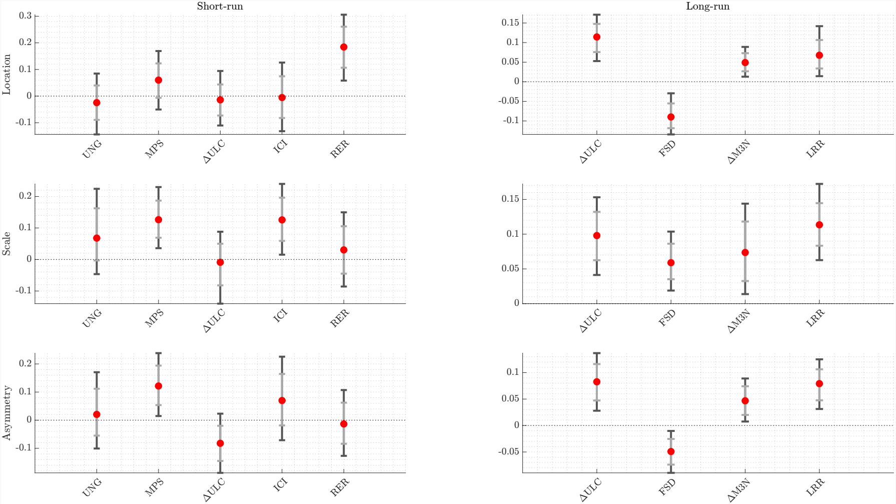
What moves inflation?



Note: 68 and 95% credible sets.

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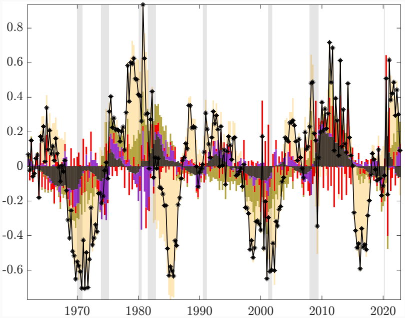
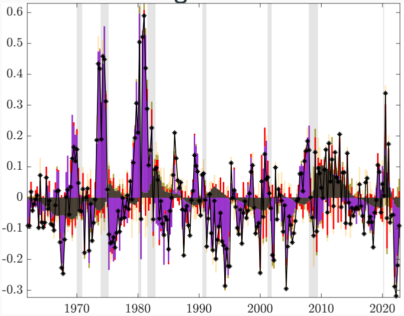
Short-run predictors

Location



Log-scale



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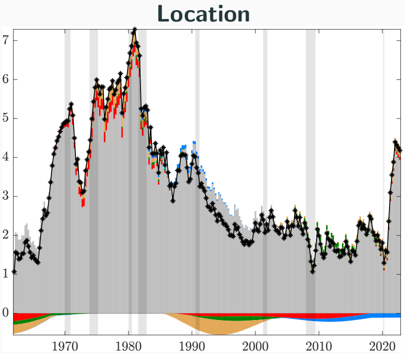
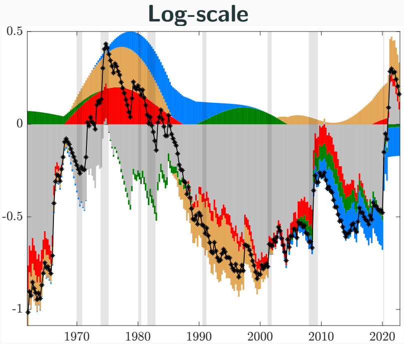
Long-run predictors





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