In Search of a Nominal Anchor: What Drives Inflation Expectations?

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Motivation

- Successful monetary policymaking relies on **anchored** inflation expectations.
- Yet: do not know much about what drives long-term expectations.
- Under what conditions are expectations anchored?
- In most macro-models **long-term** inflation expectations are:
  - Assumed to be constant; or
  - Assumed to drift exogenously.
- Stability of long-run inflation expectations should not be taken for granted — not an inherent feature of the economy.

This Paper

- Simple model of expectation formation based on learning.
- Price-setting agents act as econometricians: estimate average long-run inflation.
- **Key feature 1**: state-dependent sensitivity of long-run inflation expectations to short-term inflation surprises.

  ⇒ Generates unanchoring of long-term inflation expectations in response to large and persistent surprises.
- **Key feature 2**: with nominal rigidities expected future inflation matters for current prices.

  ⇒ Expectations are partially self-fulfilling, producing an **endogenous** inflation trend.

This Paper - ctd.

- Can such a model explain the evolution of long-term inflation expectations as measured by survey forecasts?
- Estimate the model using **only** actual inflation and survey-based measures of **short-term** inflation forecasts.
- Evaluate predictions for **long-term** survey forecasts for US and other countries (Japan, Sweden, UK, France, Germany).
- Find that model explains long-term inflation forecasts very well in all countries.
- Model detects episodes of unanchoring that accord with common wisdom.

Literature

- Inflation dynamics under learning
  - Chevillonet al. (2010), Cornea et al. (2013), Lansing (2008), Milani (2005), Primiceri (2008), Sargent et al. (2005).
- Inflation drift
  - Cogley and Sbordone (2010), Cogley et al. (2007), Del Negro et al. (2013).
- State dependent gain/ Model selection
  - State dependent gain: Marcet and Nicolini (2003), Gaus (2014), Kostyshyna (2012), Milani (2006).
  - Model selection: Brock and Hommes (1997), Evans et al.(2012).

A Simple Model

- Forecasting model of price-setting agents:

$$\pi_t = (1 - \gamma_p)\,\bar{\pi}_t + \gamma_p \pi_{t-1} + \varphi_t.$$

  - $\bar{\pi}_t$: long-run mean of inflation unknown to agents who estimate it from the data

$$\hat{E}_t \lim_{T \to \infty} \pi_T = \bar{\pi}_t.$$

  - φ_t: a zero mean stationary "short-run component"

$$\varphi_t = s_t + \mu_t$$

$$s_t = \rho_s s_{t-1} + \epsilon_t.$$

  - s_t, μ_t: relate to marginal cost and cost-push shocks in NK model.

A Simple Model - ctd.

- True inflation DGP:

$$\pi_t = (1 - \gamma_p)\,\Gamma \bar{\pi}_t + \gamma_p \pi_{t-1} + \varphi_t.$$

- Γ: measures **feed-back** from beliefs to actual inflation.

  $\Rightarrow$ In NK model: feed-back to price-setting decisions.

- $\Gamma < 1$: restricted to ensure π_t is stationary.

- True DGP for inflation has a constant mean which agents will eventually learn

The New Keynesian Phillips Curve

- Firm i maximizes the present discounted value of profits

$$E_t \sum_{T=t}^{\infty} \alpha^{T-t} Q_{t,T} \left[Y_T(i) \left(\frac{P_t(i)}{P_T} - MC_T \right) \right],$$

where $Q_{t,T}$ is the discount factor, MC_t is the real marginal cost and

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\theta_{p,t}} Y_t$$

the demand the firm faces with time-varying elasticity $\theta_{p,t}$.

- Each period the firm's price is reset optimally with probability α, and with prob $(1-\alpha)$ is indexed to a weighted average of past inflation and the perceived long-run inflation rate:

$$\bar{\Pi}_t^p = \bar{\pi}_t^{1-\gamma_p} \pi_{t-1}^{\gamma_p}.$$

The New Keynesian Phillips Curve - ctd.

- Optimal price in a model with Calvo pricing and indexation to past inflation and estimated inflation mean

$$\hat{p}_t^* = \hat{E}_t \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} \left[(-\alpha\beta)\,\varphi_T + \alpha\beta\left(\pi_{T+1} - \gamma_p \pi_T - (1-\gamma_p)\bar{\pi}_t\right)\right]$$

- Aggregating

$$\begin{aligned}\pi_t &= \gamma_p \pi_{t-1} + (1-\gamma_p)\bar{\pi}_t + \\ &\quad \hat{E}_t \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} \left[\kappa\varphi_T + (1-\alpha)\,\beta\left(\pi_{T+1} - \gamma_p \pi_T - (1-\gamma_p)\bar{\pi}_t\right)\right]\end{aligned}$$

- Soving for expectations, the DGP is

$$\pi_t = \gamma_p \pi_{t-1} + (1-\gamma_p)\Gamma\bar{\pi}_t + \frac{(1-\alpha\beta)\,(1-\alpha)}{(1-\alpha\beta\rho_s)} s_t + \mu_t$$

Learning about the Inflation Trend

- We assume the following learning algorithm:

$$\bar{\pi}_t = \bar{\pi}_{t-1} + k_{t-1}^{-1} \times f_t \text{ where } \quad f_t = \pi_t - \hat{E}_{t-1}\pi_t.$$

- In the spirit of Marcet and Nicolini (2003), learning gain $k_t > 1$:

$$k_t = \begin{cases} k_{t-1} + 1, \text{ if } \frac{\left|\hat{E}_{t-1}\pi_t - \mathbb{E}_{t-1}\pi_t\right|}{\sqrt{\mathbb{E}[\pi_t - \mathbb{E}_{t-1}\pi_t]^2}} < \nu \\ \bar{g}^{-1}, \text{ otherwise.} \end{cases}$$

- $\mathbb{E}_{t-1}\pi_t$: model-consistent forecast.

$\Rightarrow$ Captures effort to protect against structural change.

$\Rightarrow$ Use statistical tools to detect time-variation in their model's intercept.

Learning about the Inflation Trend - ctd.

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- More intuition:

$$\left|\hat{E}_{t-1}\pi_t - \mathbb{E}_{t-1}\pi_t\right| = \left|(1-\gamma_p)(1-\Gamma)\left[\bar{\pi}_0 + \sum_{\tau=0}^{t} k_\tau^{-1} f_\tau\right]\right|, \text{ given } \bar{\pi}_0, f_0, k_0.$$

$\Rightarrow$ Large when past forecast errors are of same sign for a few periods.

Anchored Expectations?

- **Anchored expectations**: agents learn about a constant long-run mean of inflation (**Least Squares**)

  $\Rightarrow$ Sensitivity of long-term expectations to short-term forecast errors decreasing with time: $k_t^{-1} \to 0$.

- **Unanchored expectations**: agents doubt the constancy of long-run inflation and put more weight on recent inflation (**Constant gain**)

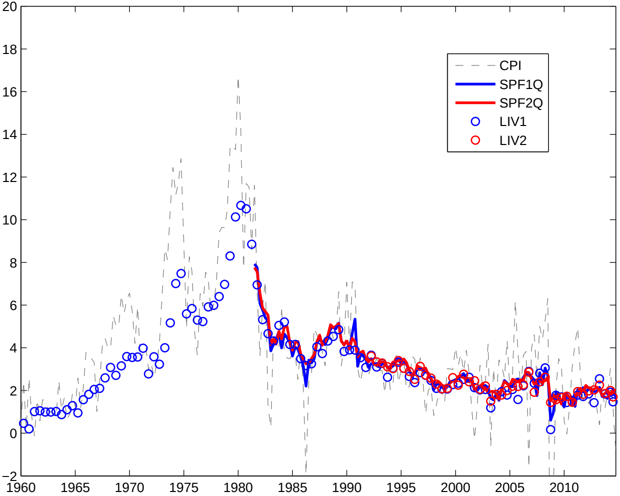
  $\Rightarrow$ Sensitivity of long-term expectations to short-term forecast errors does not change over time: $k_t^{-1} = \bar{g}$.

  $\Rightarrow$ Captures agents' attempts to protect against "structural change": constant gain produces better forecasts when economic environment changes but does not converge in stationary environment.

Data: US

- **Strategy**: given agents' updating rule use measures of short-term forecasts and inflation to infer their long-term forecasts.
- **Goal**: evaluate the model's ability to explain long-term inflation forecasts observed in survey data.
- Data: CPI inflation (quarterly), 1955Q1-2014Q4.
- Short-term forecasts (consensus):
  - 6-months ahead: Livingston survey (semi-annual), 1955Q2-2014Q4.
  - 1- and 2- quarters ahead: Survey of Professional Forecasters (quarterly), 1981Q3-2014Q4.

US: Actual Inflation and Short-Term Survey Forecasts



Estimation: US

- Model in state-space form:

$$\xi_t = F(k_{t-1}^{-1})\xi_{t-1} + S_C\epsilon_t.$$

- Observation equation:

$$Y_t^{US} = \begin{bmatrix} \pi_t \\ \mathbf{E}_t^{SPF}\pi_{t+1} \\ \mathbf{E}_t^{SPF}\pi_{t+2} \\ \mathbf{E}_t^{LIV_1}\left(\frac{1}{2}\sum_{i=1}^{2}\pi_{t+i}\right) \\ \mathbf{E}_t^{LIV_2}\left(\frac{1}{2}\sum_{i=1}^{2}\pi_{t+i}\right) \end{bmatrix} = \pi^* + H_t'\xi_t + o_t.$$

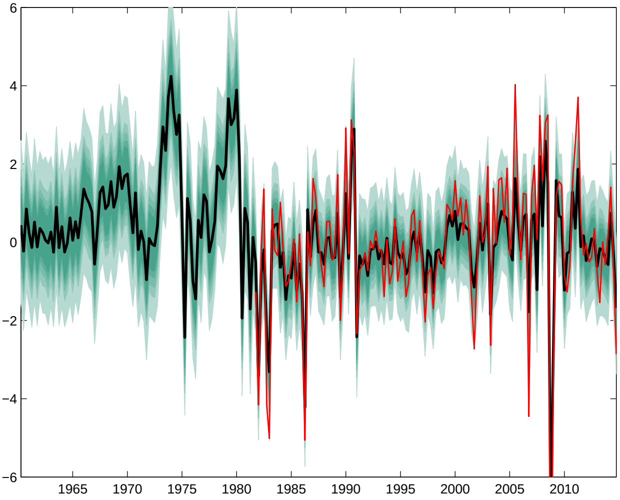
- Estimate with Bayesian methods — structural parameters:

$$\bar{\theta} = \begin{pmatrix} \pi^* & \nu & \bar{g} & \gamma_p & \Gamma & \rho_s & \sigma_s^2 & \sigma_\mu^2 \end{pmatrix}'.$$

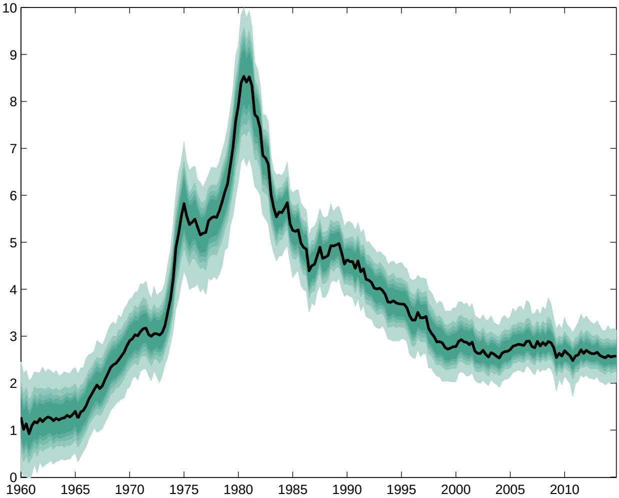
US Estimates - Table of Priors and Posteriors

	Prior				Posterior				
	Dist.	Mean	SD	Mode	Mean	SD	5%	Med.	95%
$4\pi^*$	Normal	2.0	1.2	2.21	2.49	.29	1.96	2.50	2.90
ν	Gamma	.02	.006	.019	.022	.006	.013	.022	.033
g	Gamma	.10	.050	.124	.126	.028	.083	.124	.174
Γ	Beta	.7	.150	.952	.906	.041	.823	.914	.957
γ_p	Beta	.5	.260	.124	.140	.029	.095	.138	.191

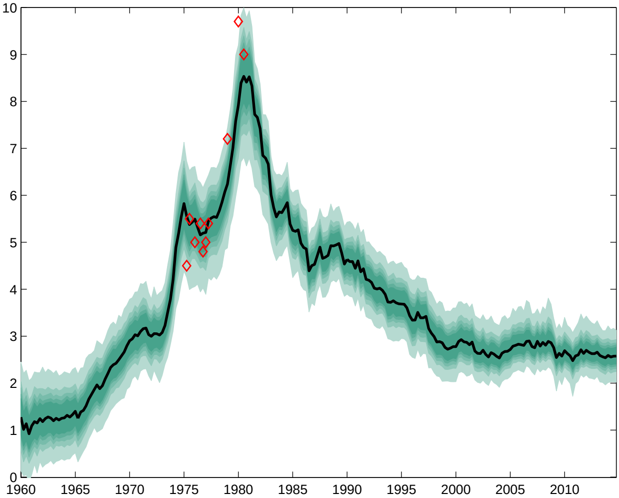
1Q Ahead Forecast Errors: Model-Implied and SPF



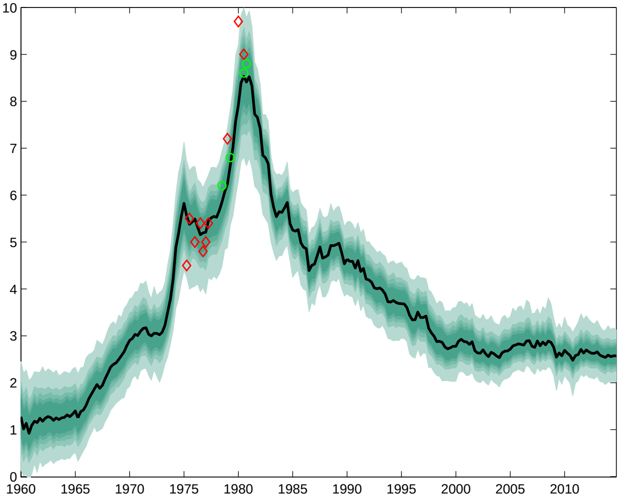
Long-term (6-10 Years) Model-Implied Inflation Forecasts



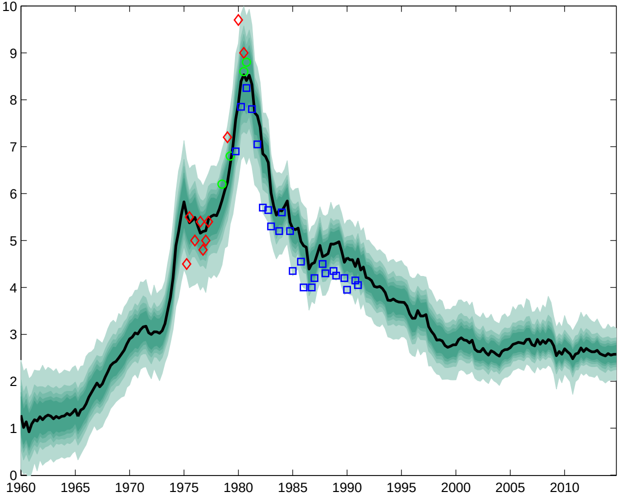
Adding Michigan Survey 6-10 Years



Adding Decision Makers Poll 1-10 Years



Adding Blue Chip Economic Indicators 1-10 Years



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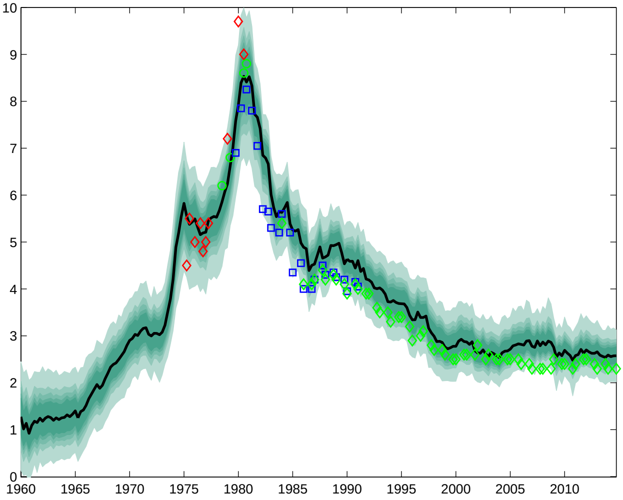
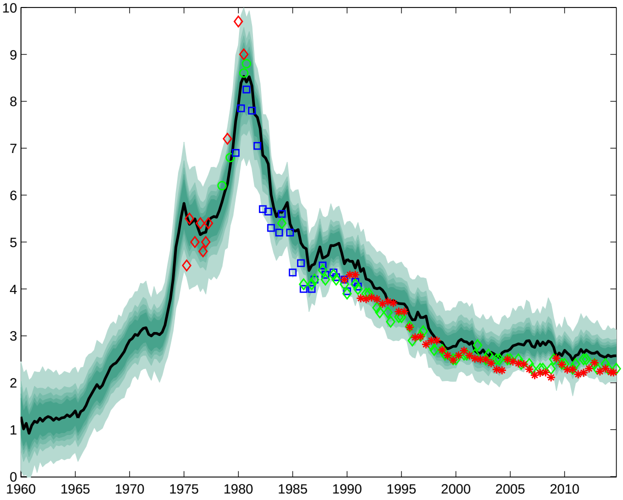
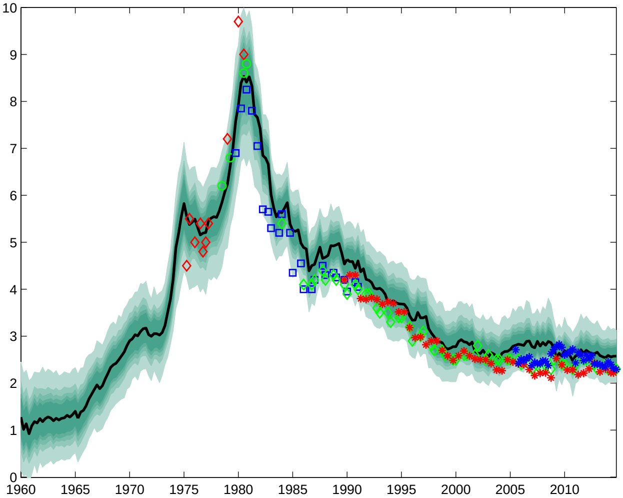


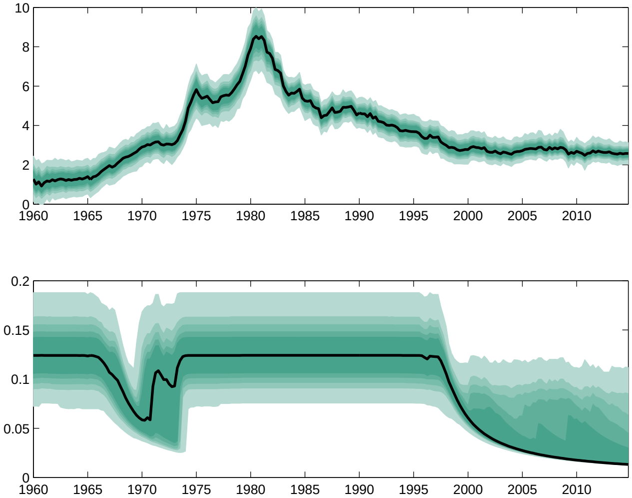
Adding Consensus Economics 6-10 Years



Adding Survey of Professional Forecasters 6-10 Years



Estimated Gain k_t^{-1}



Comparing to Model with Exogenous Inflation Drift

- Popular approach both in reduced-form and DSGE models

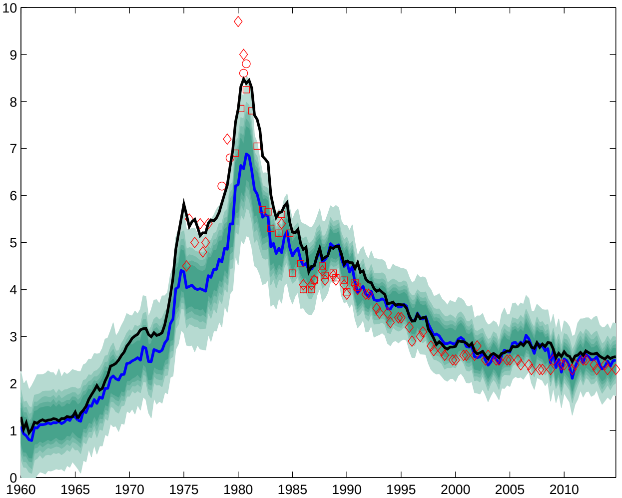
$$\bar{\pi}_{t+1} = \rho_{\bar{\pi}} \bar{\pi}_t + e_t ; \rho_{\bar{\pi}} \approx 1.$$

- To compare, our model implies

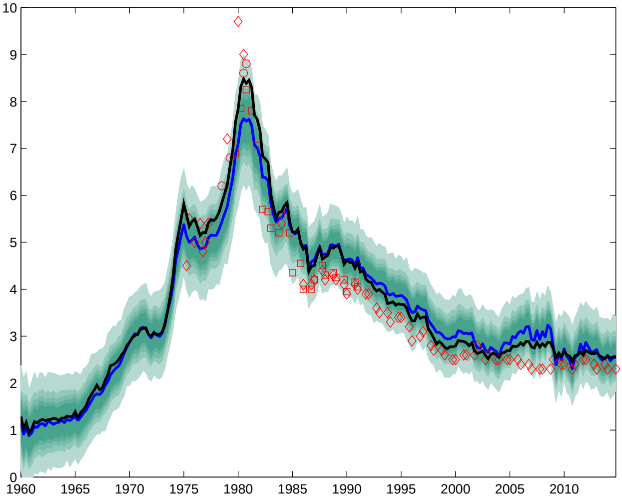
$$\begin{aligned} \bar{\pi}_{t+1} &= \bar{\pi}_t + k_t^{-1} \left(\pi_t - \hat{E}_{t-1} \pi_t \right) \\ &= \underbrace{\left[1 + k_t^{-1} \left(1 - \gamma_p \right) \left(\Gamma - 1 \right) \right]}_{\rho_{\bar{\pi},t}} \bar{\pi}_t + \underbrace{k_t^{-1} \left(\epsilon_t + \mu_t \right)}_{\tilde{e}_t} . \end{aligned}$$

- Key differences:
  - Persistence and volatility are time-varying and state-dependent.
  - Innovations to $\bar{\pi}_t$ depend on inflation forecast errors: *endogenous drift.*

Model Comparison: Exogenous Drift



Model Comparison: Constant Gain



Estimation: Other Countries

- Data:
  - Consumer Price Indices: late 1950s to 2014Q4.
  - Short-term forecasts from Consensus Economics (1991-2014Q4).
- **Data limitations**:
  - Limited sample of surveys + year-over-year forecasts.
  - Forecasts for current year include quarterly forecasts of 1-2 quarters ahead.
  - Forecasts for the following year give highest weight to 1-4 quarters ahead forecasts.
  - Not a precise measure of one-quarter-ahead prediction errors.

Estimation: Other Countries - ctd.

- Solution: for "structural" params use US posterior as prior for these countries.
- For π^* and *and obs. errors* use same prior distributions as for the US.
- Posterior:

$$
\begin{aligned}
P^*\left(\theta^* | Y_t^*, Y_t^{US}, \theta^{US}\right) &= \lambda^* \ln L(Y_t^* | \theta^{US}, \theta^*) + \\
&\ln \left[L(Y_t^{US} | \theta^{US}) p(\theta^{US}) \right] + \\
&\ln p(\theta^*).
\end{aligned}
$$

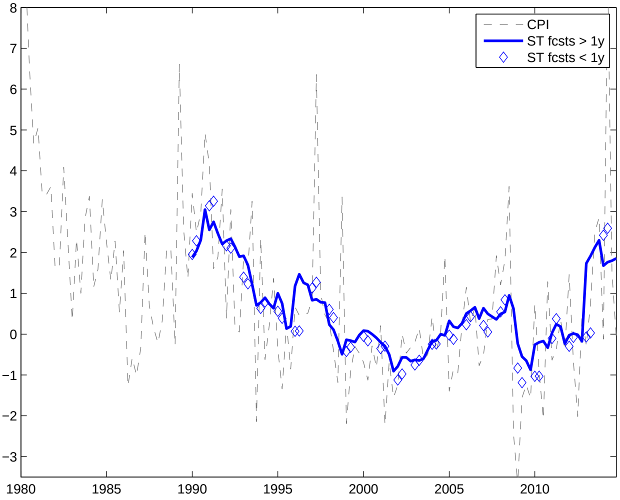
- λ^*: use alternative weights on foreign country's Likelihood
  $\Rightarrow$ Small λ^*: Model predictions using US posterior distribution.
- We consider $\lambda^* = 0.2$ and 0.5.

Posteriors for All Countries ($\lambda^* = 0.5$)

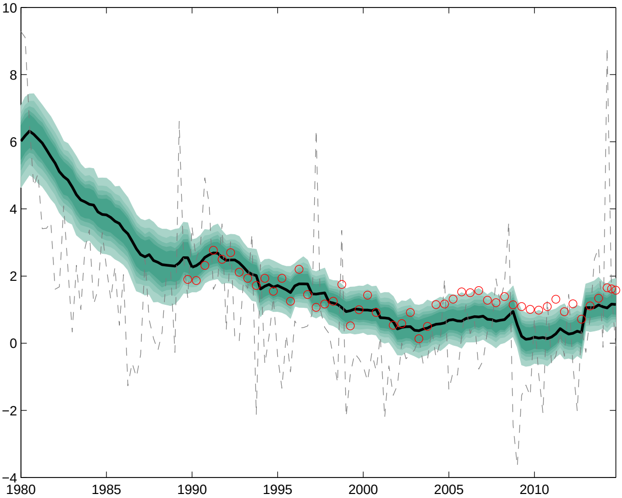
	US			Japan			France		
	5%	Med.	95%	5%	Med.	95%	5%	Med.	95%
$4\pi^*$	1.96	2.50	2.90	1.12	1.81	2.55	1.35	1.81	2.24
g	.083	.124	.174	.081	.139	0.193	.188	.269	.360
Γ	.823	.914	.957	.847	.924	.963	.923	.953	.973
γ_p	.095	.138	.191	.093	.140	.203	.060	.106	.156

	Germany			Sweden			UK		
$4\pi^*$	1.32	1.91	2.62	1.50	2.07	2.63	1.48	2.08	2.66
g	.112	.155	.216	.039	.072	.150	.028	.052	.079
Γ	.847	.915	.956	.730	.892	.953	.560	.830	.937
γ_p	.099	.150	.215	.084	.119	.177	.082	.103	.131

Japan: Consumer Price Inflation and Short-Term Forecasts



Japan: Model-Implied and Observed Long-Term Forecasts



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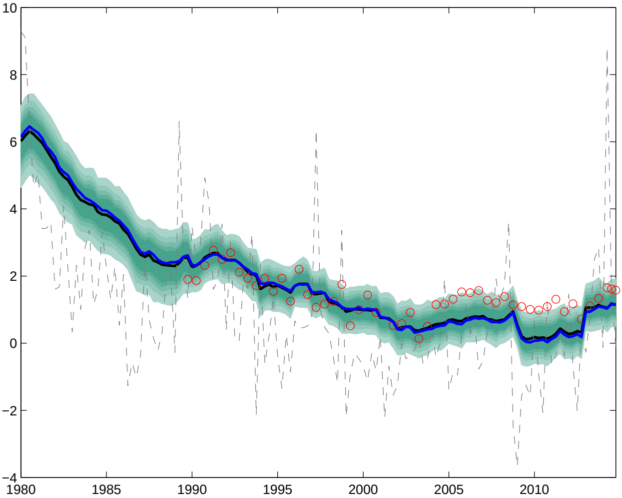
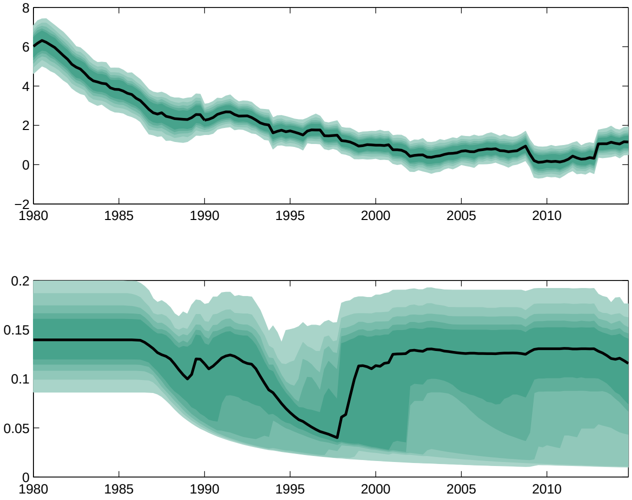
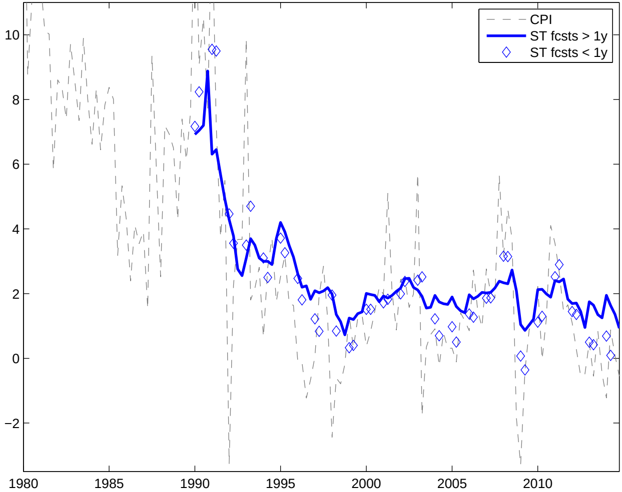


Japan: Learning Gain ($\lambda^* = 0.5$)



Sweden: Consumer Price Inflation and Short-Term Fcsts



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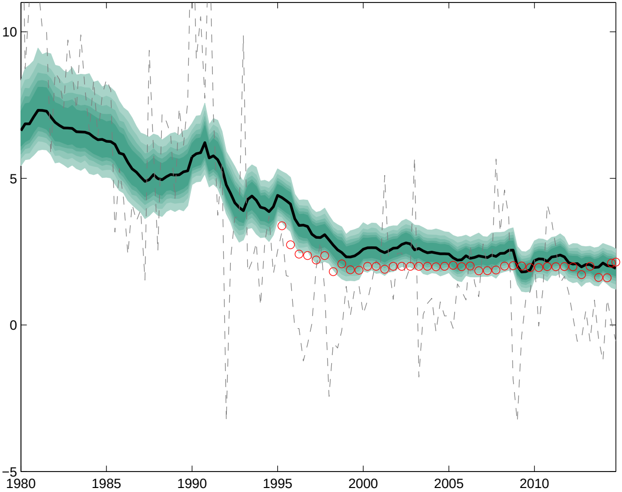

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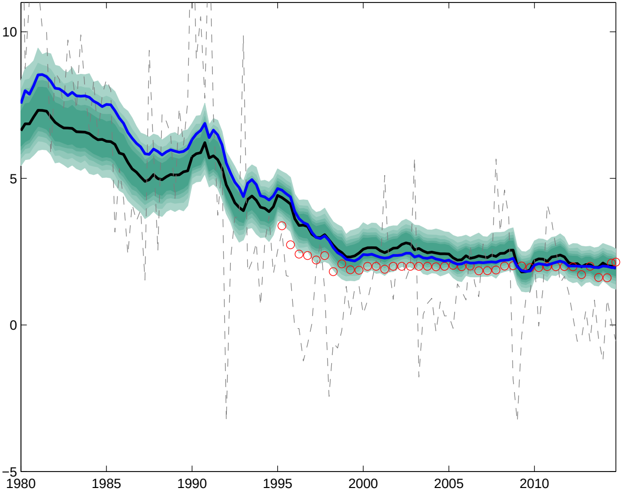

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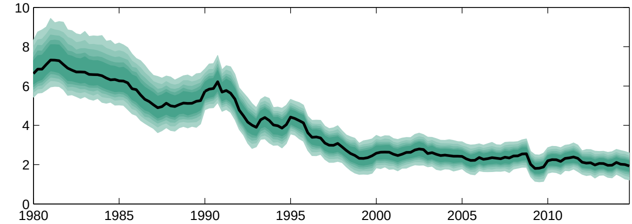
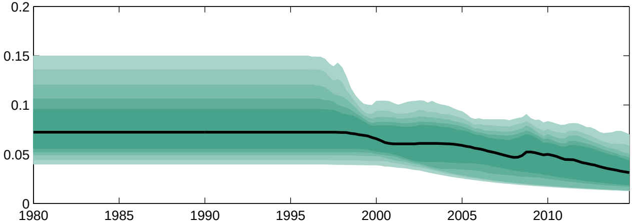
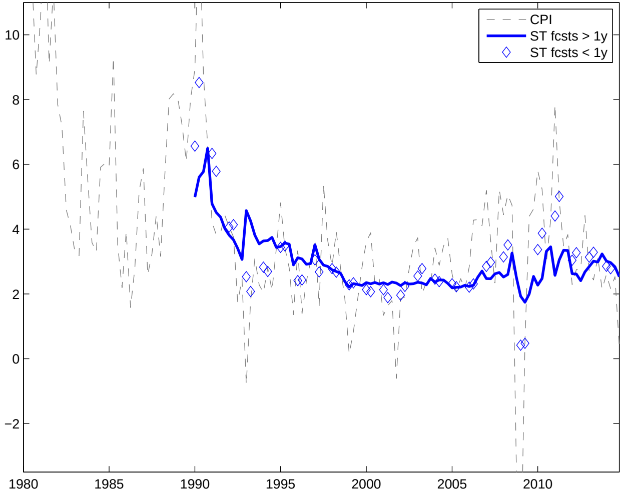
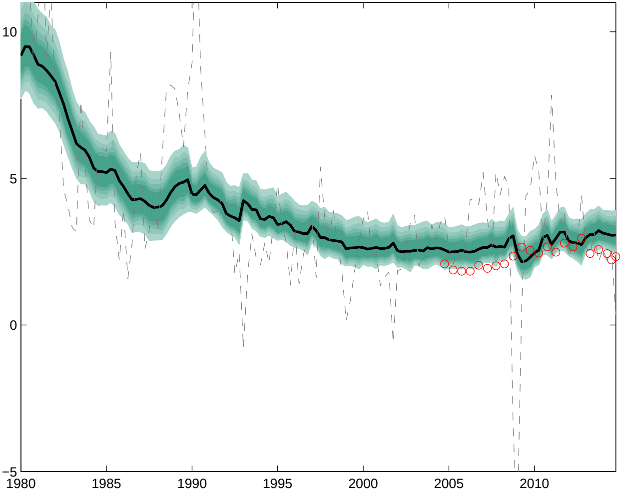




UK: Consumer Price Inflation and Short-Term Fcsts



UK: Model-Implied and Observed Long-Term Fcsts



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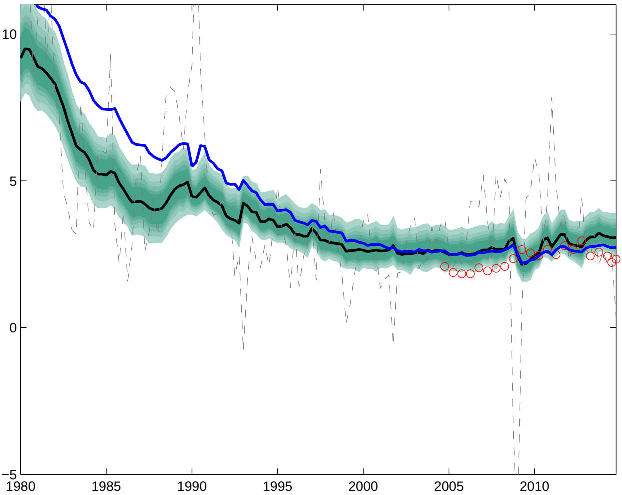

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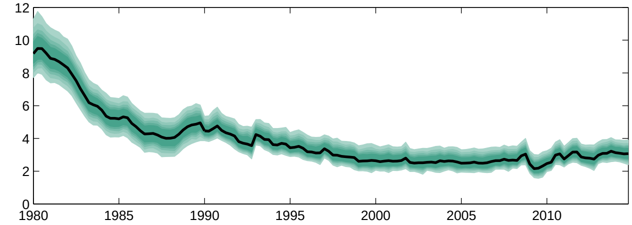
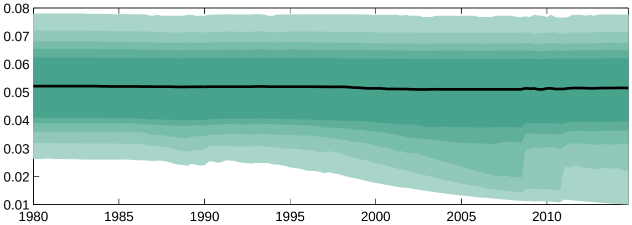
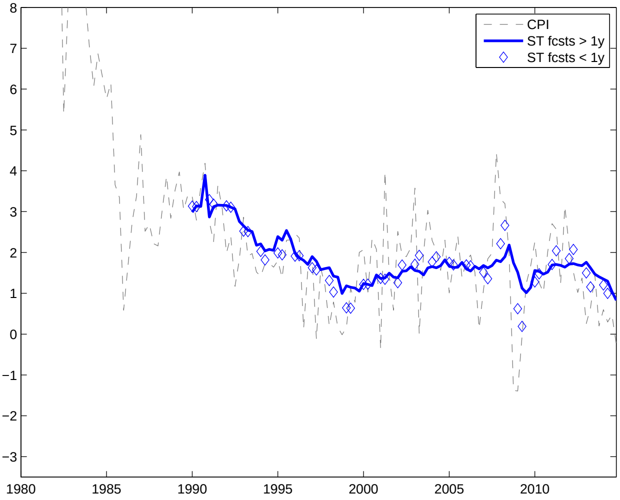
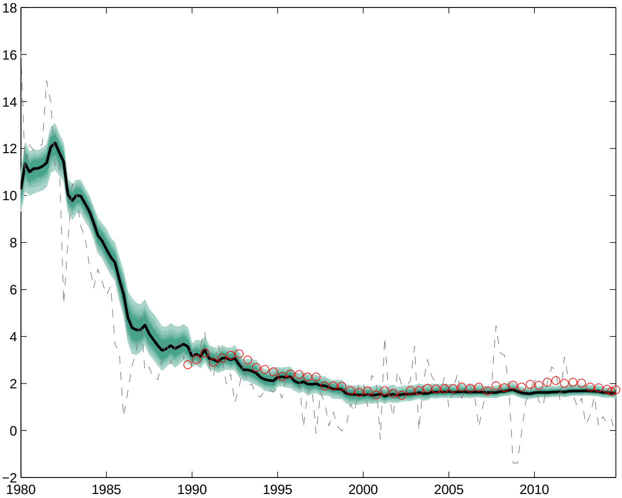




France: Consumer Price Inflation and Short-Term Fcsts



France: Model-Implied and Observed Long-Term Forecasts



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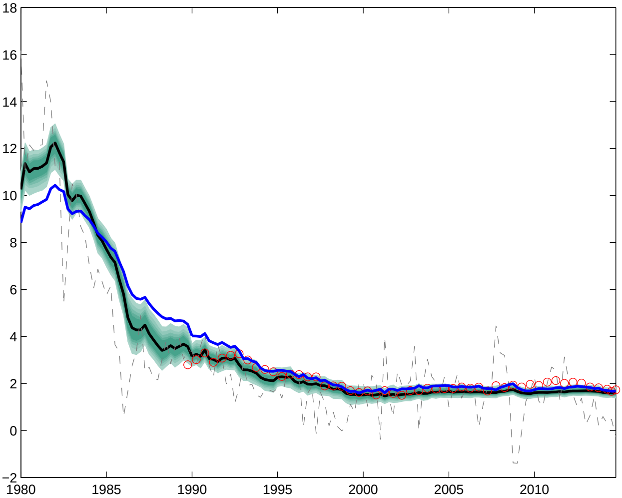

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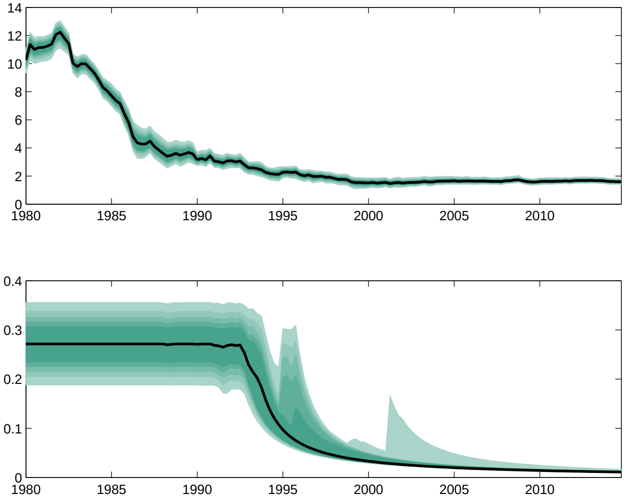
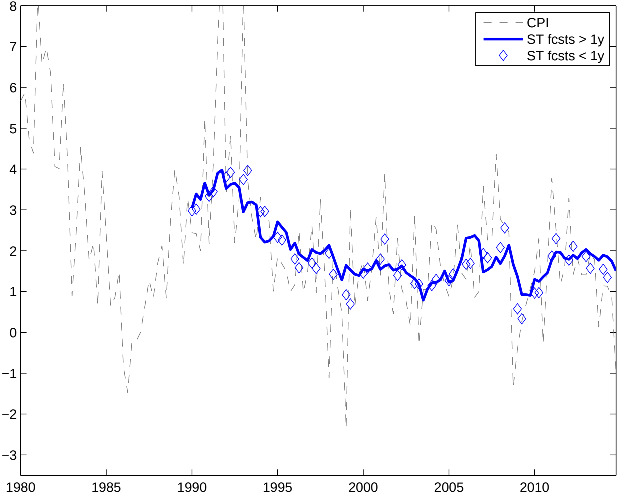
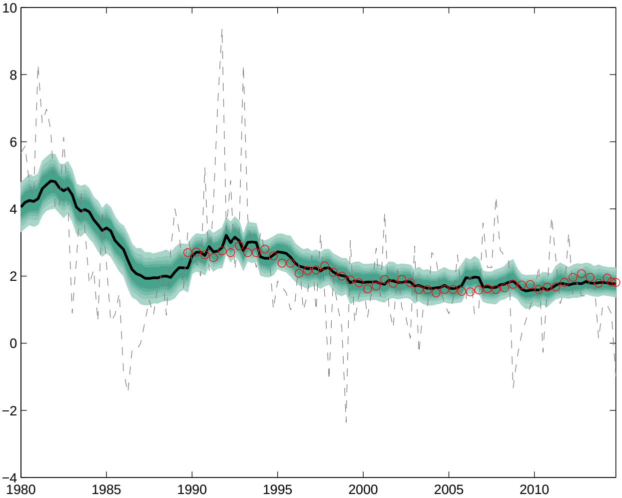


Germany: Consumer Price Inflation and Short-Term Fcsts



Germany: Model-Implied and Observed Long-Term Fcsts



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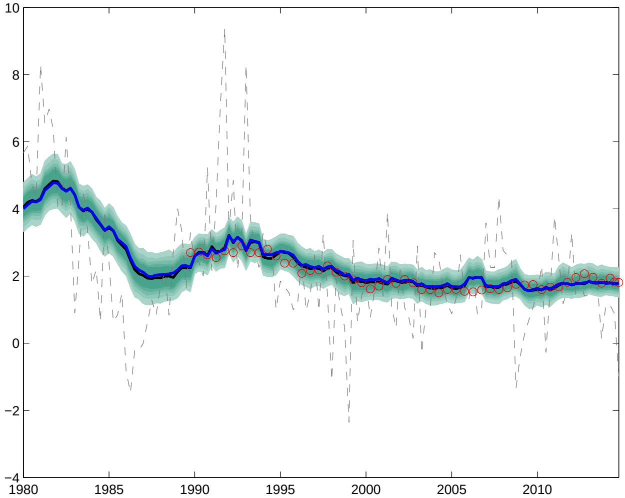

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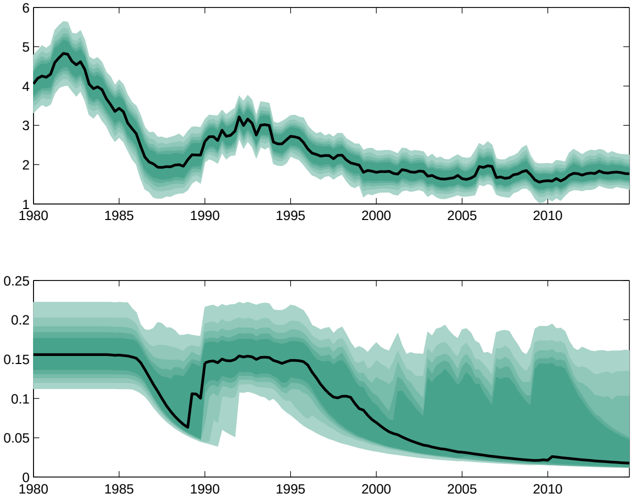

Summary of Results for Other Countries

1. Model characterizes well the evolution of long-term forecasts.

   ⇒ Survey-based forecasts are inside the 95% bands for most of the sample.

2. Except for Japan, all countries recently have had anchored inflation expectations.

3. Germany: episode of unanchoring in 1990s.

Conclusion

- Simple learning model which links long-term inflation expectations to short-term forecast errors.
- In model inflation and inflation expectations can become unmoored in response to large and persistence short-term forecast errors.
- Model describes long-term survey forecasts of inflation very well for number of countries despite using only inflation and short-term forecasts in estimation.
- In our model short-term forecast errors are treated as exogenous...
- ...but in full general equilibrium model they depend on policy regime.