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

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The views expressed here are the authors’ and are not representative of the views of Deutsche Bundesbank, the Eurosystem, the Federal Reserve Bank of New York or of the Federal Reserve System.
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.
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
  - Chevillon et al. (2010), Cornea et al. (2013), Lansing (2008), Milani (2005), Primiceri (2008), Sargent et al. (2005).

- Inflation drift

- State dependent gain/ Model selection
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

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

- $\varphi_t$: a zero mean stationary “short-run component”

\[
\varphi_t = s_t + \mu_t
\]

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

- $s_t, \mu_t$: relate to marginal cost and cost-push shocks in NK model.
A Simple Model - ctd.

- True inflation DGP:

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

- \( \Gamma \): measures **feed-back** from beliefs to actual inflation.

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

- \( \Gamma < 1 \): restricted to ensure \( \pi_t \) 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 $\alpha$, and with prob $(1 - \alpha)$ is indexed to a weighted average of past inflation and the perceived long-run inflation rate:

$$\bar{\pi}_t^p = \bar{\pi}_t^{1-\gamma_p} \pi_t^{\gamma_p} \bar{\pi}_{t-1}.$$
The New Keynesian Phillips Curve - ctd.

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

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

- Aggregating

\[
\pi_t = \gamma_p \pi_{t-1} + (1 - \gamma_p) \bar{\pi}_t +
\]

\[
\hat{E}_t \sum_{T=t}^{\infty} (\alpha \beta)^{T-t} [\kappa \varphi_T + (1 - \alpha) \beta (\pi_{T+1} - \gamma_p \pi_T - (1 - \gamma_p) \bar{\pi}_t)]
\]

- Solving for expectations, the DGP is

\[
\pi_t = \gamma_p \pi_{t-1} + (1 - \gamma_p) \bar{\pi}_t + \frac{(1 - \alpha \beta)(1 - \alpha)}{1 - \alpha \beta \rho_s} s_t + \mu_t
\]
Learning about the Inflation Trend

- We assume the following learning algorithm:

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

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

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

- \( \mathbb{E}_{t-1}\pi_t \): 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.

- We assume the following learning algorithm:

\[ \tilde{\pi}_t = \tilde{\pi}_{t-1} + k_{t-1}^{-1} \times f_t \] where \[ f_t = \pi_t - \hat{E}_{t-1}\pi_t. \]

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  \bar{g}^{-1}, & \text{otherwise.}
\end{cases}
\]

- More intuition:

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

\( \Rightarrow \) 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**)

  ⇒ 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**)

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

  ⇒ 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.


Short-term forecasts (consensus):

  - 6-months ahead: Livingston survey (semi-annual), 1955Q2-2014Q4.
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:

\[
Y_{t}^{US} = \begin{bmatrix}
\pi_t \\
E_t^{SPF}\pi_{t+1} \\
E_t^{SPF}\pi_{t+2} \\
E_t^{LIV1}\left(\frac{1}{2}\sum_{i=1}^{2}\pi_{t+i}\right) \\
E_t^{LIV2}\left(\frac{1}{2}\sum_{i=1}^{2}\pi_{t+i}\right)
\end{bmatrix}
= \pi^* + H'_t\xi_t + o_t.
\]

- Estimate with Bayesian methods — structural parameters:

\[
\bar{\theta} = \left(\begin{array}{cccccc}
\pi^* & \nu & \bar{g} & \gamma_p & \Gamma & \rho_s & \sigma_s^2 & \sigma_\mu^2
\end{array}\right)'.
\]
## US Estimates - Table of Priors and Posteriors

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Prior</th>
<th>Mean</th>
<th>SD</th>
<th>Mode</th>
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<td>.138</td>
<td>.191</td>
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1Q Ahead Forecast Errors: Model-Implied and SPF
Long-term (6-10 Years) Model-Implied Inflation Forecasts
Adding Decision Makers Poll 1-10 Years
Adding Blue Chip Economic Indicators 1-10 Years
Adding Blue Chip Economic Indicators 6-10 Years
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

\[ \bar{\pi}_{t+1} = \bar{\pi}_t + k_t^{-1} \left( \pi_t - \hat{E}_{t-1} \pi_t \right) \]
\[ = \left[ 1 + k_t^{-1} (1 - \gamma_p) (\Gamma - 1) \right] \bar{\pi}_t + k_t^{-1} (\epsilon_t + \mu_t). \]

- 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

[Graph showing exogenous drift over time from 1960 to 2010]
Model Comparison: Constant Gain
Estimation: Other Countries

- **Data:**

- **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 $\pi^*$ and *obs. errors* use same prior distributions as for the US.

- Posterior:

$$P^* \left( \theta^* \mid Y_t^*, Y_t^{US}, \theta^{US} \right) = \lambda^* \ln L(Y_t^* \mid \theta^{US}, \theta^*) +$$

$$\ln \left[ L(Y_t^{US} \mid \theta^{US}) p(\theta^{US}) \right] +$$

$$\ln p(\theta^*).$$

- $\lambda^*$: use alternative weights on foreign country’s Likelihood
  ⇒ Small $\lambda^*$: Model predictions using US posterior distribution.

- We consider $\lambda^* = 0.2$ and 0.5.
## Posteriors for All Countries ($\lambda^* = 0.5$)

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Japan: Consumer Price Inflation and Short-Term Forecasts

![Graph showing consumer price index (CPI) and short-term forecasts (ST fcsts) from 1980 to 2010. The graph includes CPI data and short-term forecasts both greater than 1 year and less than 1 year.](image-url)
Japan: Model-Implied and Observed Long-Term Forecasts
Japan: Model-Implied and Observed Long-Term Forecasts
Japan: Learning Gain ($\lambda^* = 0.5$)
Sweden: Consumer Price Inflation and Short-Term Fcsts
Sweden: Model-Implied and Observed Long-Term Fcsts
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Germany: Model-Implied and Observed Long-Term Fcsts
Germany: Learning Gain ($\lambda^* = 0.5$)
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.

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.