Long-run inflation expectations by professional forecasters

Figure: Long-run CPI inflation expectations, US SPF (1991q4-2023q1)
Looking behind average expectations

**Figure:** Long-run inflation expectations by selected forecasters

- Highly heterogeneous patterns → wealth of information in the cross-section
This paper

▶ Model to understand fluctuations in individual expectations
   → implications for behavior of average expectations
This paper

- Model to understand fluctuations in individual expectations
  → implications for behavior of average expectations

- Trend-cycle model of inflation with time-varying parameters

- Forecasters observe three signals to track trend inflation:
  
  1. Inflation signal: trend + cycle + iid
  2. Common signal: trend + common sentiments
  3. Idiosyncratic signal: trend + idiosyncratic sentiments
This paper

- Model to understand fluctuations in individual expectations → implications for behavior of average expectations

- Trend-cycle model of inflation with time-varying parameters

- Forecasters observe three signals to track trend inflation:
  1. Inflation signal: trend + cycle + iid
  2. Common signal: trend + common sentiments
  3. Idiosyncratic signal: trend + idiosyncratic sentiments

- Likelihood estimation with SPF panel data to investigate
  1. The sensitivity of expectations to the factors above
  2. What path of inflation is needed to anchor SPF expectations
Preview of main findings

1. **Low sensitivity** of expectations to **cyclical inflation**
Preview of main findings

1. **Low sensitivity** of expectations to **cyclical inflation**

2. Information in the **cross-section is critical** to accurately estimate the **sensitivity of expectations**
Preview of main findings

1. **Low sensitivity** of expectations to **cyclical inflation**

2. Information in the **cross-section is critical** to accurately estimate the **sensitivity of expectations**

3. **Coordination of beliefs** around inflation target preserved anchoring despite the low inflation after the Great Recession
Preview of main findings

1. **Low sensitivity** of expectations to *cyclical inflation*

2. Information in the **cross-section is critical** to accurately estimate the **sensitivity of expectations**

3. **Coordination of beliefs** around inflation target preserved anchoring despite the low inflation after the Great Recession

4. Dec 2022 SEP inflation inconsistent with anchored expectations and little scope for coordinating beliefs
The Model
Forecasting model

Forecasters form expectations believing inflation can be characterized by a **trend-cycle model**:

\[
\pi_t = \bar{\pi}_t + \varepsilon_t + \sigma_\omega \omega_t
\]

Inflation \[=\] Trend \[+\] Cycle \[+\] IID

**Trend**:

\[
\bar{\pi}_t = \bar{\pi}_{t-1} + \sigma_\lambda \lambda_t
\]

**Cycle**:

\[
\varepsilon_t = \phi_t \varepsilon_{t-1} + \sigma_\eta \eta_t
\]
Forecasters’ information set

- Knowledge of the trend-cycle model
- History of inflation
- Three signals for each forecaster $i$:
  1. Inflation signal
  2. Common signal:

\[ \bar{\pi}_t + \alpha(i) v_{c,t} \quad \text{where} \quad v_{c,t} = \rho_c v_{c,t-1} + \sigma_{c,t} v_{c,t}, \quad \alpha(i) > 0 \]

3. Idiosyncratic signal:

\[ \bar{\pi}_t + v_t(i) \quad \text{where} \quad v_t(i) = \rho(i) v_{t-1}(i) + \sigma_v(i) v_{v,t}(i) \]

⇒ Forecasters solve a signal-extraction problem
Estimation
Two-step estimation

1. Estimation of inflation model

- US CPI inflation
- Sample: 1959Q1-2019Q4
Two-step estimation

2. **Panel estimation of forecasters’ signal-extraction model**
given the estimated inflation model from Step 1

- US CPI inflation
- estimated cyclical and trend component from Step 1
- individual SPF long-run CPI inflation expectations

**Proxy:**

- until 2010q4: 10Y CPI inflation expectations
- from 2011q1: 5Y5Y CPI inflation expectations

- Sample: 1991Q3-2019Q4
Inflation expectations through the lens of the model
Expectations’ sensitivity: importance of cross-section

Information in the **cross-section** key to estimate accurately the sensitivity of SPF expectations.
Historical drivers of long-term inflation expectations

Figure: Historical decomposition of selected forecasters
Historical drivers of average inflation expectations

Figure: Historical decomposition of average inflation expectations

- Permanent shocks as primary driver of average expectations
- Coordination of beliefs as stabilization factor of expectations
Anchoring US Inflation Expectations
Anchoring US Inflation Expectations

Idea: Will average long term inflation expectations be anchored going forward from any particular date and under what conditions?

Counterfactual exercises:

1. December 2015: Inflation persistently below target for years

2. December 2022: More than one year very high inflation
For each of these SEP scenarios, we estimate trend inflation

Ask the model to predict the path of average expectations
Expectations under SEP inflation paths

- Dec 15: SEP inflation paths too shallow → anchoring fails
- Dec 22: SEP inflation paths inconsistent with anchoring
Expectations under SEP inflation paths

- Dec 15: SEP inflation paths too shallow ⇒ anchoring fails
- Dec 22: SEP inflation paths inconsistent with anchoring in the absence of central bank’s communications
- Caveat: no role for sentiment shocks
Keeping long-run expectations stable

1. Target a path of stable average expectations

2. Guess a path for trend inflation $\bar{\pi}_t$

3. Given the path of average expectations and trend inflation, we ask the model what path of inflation is consistent

   Assumption: Individual sentiments are set to zero

4. Estimate trend of the inflation path from 3. to verify the guess
Keeping long-run expectations stable

1. Target a path of stable average expectations

2. Guess a path for trend inflation $\bar{\pi}_t$

3. Given the path of average expectations and trend inflation, we ask the model what path of inflation is consistent.

   Assumption: Individual sentiments are set to zero

4. Estimate trend of the inflation path from 3. to verify the guess

Two cases:

- Perfect communication: All three signals active
- No communication: Common signal inactive
Stable US inflation expectations: December 2015

▶ Perfect communication: median SEP not enough for stabilization

▶ Imperfect communication: even higher inflation overshoot needed
Stable US inflation expectations: December 2022

- Significant undershooting of SEP inflation path
- Small role of communication based on Dec 22 model estimates
Concluding Remarks

This paper: How to use panel survey data to assess

▶ the sensitivity of long-run inflation expectations
▶ what path of inflation is consistent with anchoring
This paper: How to use panel survey data to assess
▶ the sensitivity of long-run inflation expectations
▶ what path of inflation is consistent with anchoring

Key take-aways:
▶ **Low sensitivity** of expectations to **cyclical inflation**
▶ Information in the **cross-section is critical** to accurately estimate the **sensitivity of expectations**
▶ **Coordination of beliefs** around inflation target preserved anchoring despite the low inflation after the Great Recession
▶ Dec 2022 SEP inflation inconsistent with anchored expectations and little scope for coordinating beliefs
Thank you!
Appendix
Long-run inflation expectations by professional forecasters

Figure: 10Y CPI inflation expectations, US SPF (1991q4-2023q1)
Related Literature

- Modelling the dynamics of inflation and inflation expectations

- Role of central bank communications in aggregate dynamics
  Nakamura and Steinsson (2018), Gürkaynak et al. (2005), Campbell et al. (2012)

- (Professionals) survey data and expectations formation
  Clements et al. (2023), Patton and Timmermann (2010), Andrade et al. (2016), Coibion and Gorodnichenko (2015), Bianchi et al. (2023), Kohlhas and Walther (2021), Bordalo et al. (2020)

- Anchoring of inflation expectations
  1. Average long-run inflation forecasts stable and close to target
     Carvalho et al. (2020), Beechey et al. (2011), Orphanides and Williams (2005)
  2. Long-run expectations do not respond much to incoming data
     Corsello et al. (2021), Dräger and Lamla (2014), Barlevy et al. (2021), Gürkaynak et al. (2007)
  3. Defined based on higher order moments of inflation expectations
     Reis (2021), Grishchenko et al. (2019)
Inflation model

The model of inflation, $\pi_t$ is:

$$
\pi_t = \bar{\pi}_t + \varepsilon_t + \sigma \omega_t
$$
$$
\bar{\pi}_t = \bar{\pi}_{t-1} + \sigma_{\lambda,t} \lambda_t
$$
$$
\varepsilon_t = \phi_t \varepsilon_{t-1} + \sigma_{\eta,t} \eta_t
$$

where $\omega_t$, $\lambda_t$, and $\eta_t$ are i.i.d. $\mathcal{N}(0,1)$.

$$
\ln(\sigma_{\eta,t}^2) = \ln(\sigma_{\eta,t-1}^2) + \gamma_{\eta} \omega_{\eta,t}
$$
$$
\ln(\sigma_{\lambda,t}^2) = \ln(\sigma_{\lambda,t-1}^2) + \gamma_{\lambda} \omega_{\lambda,t},
$$

where $\omega_{\eta,t}$ and $\omega_{\lambda,t}$ are i.i.d. $\mathcal{N}(0,1)$.

$$
\phi_t = \phi_{t-1} + \gamma_{\phi} \omega_{\phi,t},
$$

where $\omega_{\phi,t}$ is distributed $\mathcal{N}(0,1)$ and $\phi_t \in (0,1)$.  

\(\text{back}\)
Forecasters’ long-run inflation expectations

Forecasters state-space model can be written as

\[ \xi_t(i) = \Phi_t(i)\xi_{t-1}(i) + R_t(i)e_t(i) \]  
\[ s_t(i) = D(i)\xi_t(i) + \Psi u_t \]

where

\[ \xi_t(i) = [\varepsilon_t, \bar{\pi}_t, \nu_{c,t}, \nu_t(i)]' \]
\[ e_t(i) = [\eta_t, \lambda_t, \nu_{c,t}, \nu_t(i)]' \]
\[ s_t(i) = [s_{1,t}, s_{2,t}(i), s_{3,t}(i)]' \]

\[ \Rightarrow \text{Forecasters update expectations about states using Bayes rule} \]
\[ \xi_{t|t}(i) \equiv \mathbb{E}(\xi_t(i)|s_t(i), \pi^{t-1}) = (I_4 - K_t(i)D(i))\xi_{t|t-1}(i) + K_t(i)s_t(i) \]

where \( K_t(i) \) denotes Kalman gain.
Kalman filter derivation

The Kalman filter recursion is given by:

\[
\begin{align*}
\xi_{t|t-1}(i) & = \Phi_t(i)\xi_{t-1|t-1}(i) \\
P_{t|t-1}(i) & = \Phi_t(i)P_{t-1|t-1}(i)\Phi_t(i)' + R_t(i)R_t(i)' \\
s_{t|t-1}(i) & = D(i)\xi_{t|t-1}(i) \\
F_{t|t-1}(i) & = D(i)P_{t|t-1}(i)D(i)' + \Psi\Psi' \\
\end{align*}
\]

\[
\xi_{t|t}(i) = \xi_{t|t-1}(i) + P_{t|t-1}(i)D(i)' \left[ F_{t|t-1}(i) \right]^{-1} \left[ s_t(i) - D(i)\xi_{t|t-1}(i) \right]
\]

\[
P_{t|t}(i) = P_{t|t-1}(i) - P_{t|t-1}(i)D(i)' \left[ F_{t|t-1}(i) \right]^{-1} D(i)P_{t|t-1}(i)
\]

Then, re-arrange the Kalman equation as follows:

\[
\begin{align*}
\xi_{t|t}(i) & = \xi_{t|t-1}(i) + K_t(i) \left[ s_t(i) - D(i)\xi_{t|t-1}(i) \right] \\
& = [I_4 - K_t(i)D(i)]\Phi_t(i)\xi_{t-1|t-1}(i) + K_t(i)s_t(i) \\
& = [I_4 - K_t(i)D(i)]\Phi_t(i)\xi_{t-1|t-1}(i) + K_t(i)[D(i)\xi_t(i) + \Psi u_t] \\
& = [I_4 - K_t(i)D(i)]\Phi_t(i)\xi_{t-1|t-1}(i) \\
& + K_t(i)[D(i)(\Phi_t(i)\xi_{t-1}(i) + R_t(i)e_t(i)) + \Psi u_t]
\end{align*}
\]
Estimation of inflation model

**Data:** US CPI inflation, quarter-on-quarter annualized growth rates

**Sample:** 1959Q1-2019Q4

**Parameters:**

<table>
<thead>
<tr>
<th></th>
<th>Shape</th>
<th>Scale</th>
<th>Mean</th>
<th>[5%, 95%]</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_1^2$</td>
<td>5</td>
<td>0.04</td>
<td>0.01</td>
<td>[0.004,0.02]</td>
<td>0.0497</td>
</tr>
<tr>
<td>$\gamma_2^2$</td>
<td>5</td>
<td>0.04</td>
<td>0.01</td>
<td>[0.004,0.02]</td>
<td>0.0104</td>
</tr>
<tr>
<td>$\gamma_3^2$</td>
<td>5</td>
<td>0.004</td>
<td>0.001</td>
<td>[0.0004,0.002]</td>
<td>0.0014</td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>3</td>
<td>0.2</td>
<td>0.1</td>
<td>[0.032,0.245]</td>
<td>0.1520</td>
</tr>
</tbody>
</table>

**Table:** Prior and posterior for parameters distributed as Inverse Gamma (Shape,Scale)
Figure: Time-varying parameter estimates (posterior means)
Estimation of forecaster panel model

Transition equation:

\[
\begin{bmatrix}
\xi_t \\
\xi_{t|t} \\
\omega_t
\end{bmatrix} = \tilde{\Phi}_t
\begin{bmatrix}
\xi_{t-1} \\
\xi_{t-1|t-1} \\
0
\end{bmatrix} + \tilde{R}_t
\begin{bmatrix}
\eta_t \\
\lambda_t \\
\nu_{c,t} \\
\nu_{v,t} \\
\omega_t
\end{bmatrix}
\]

\(\xi_t\): Inflation model and belief processes, i.e.
\(\xi_t = \begin{bmatrix} \varepsilon_t & \bar{\pi}_t & \nu_{c,t} & \bar{\nu}_t \end{bmatrix}'\)

\(\xi_{t|t}\): vector of individual forecasters’ expectations \(\xi_{t|t}(i)\)
Estimation of forecaster panel model

Measurement equation:

\[
\begin{bmatrix}
\pi^{cpi}_t \\
\varepsilon^*_{est_t} \\
\bar{\pi}^*_{est_t} \\
E_t \pi^*_t (1) \\
E_t \pi^*_t (2) \\
\vdots \\
E_t \pi^*_t (N)
\end{bmatrix}
= 
\begin{bmatrix}
D_{CPI} & 0_{1 \times k} & 0_{1 \times k} & \cdots & 0_{1 \times k} & \sigma_\omega \\
1_1 & 0_{1 \times k} & 0_{1 \times k} & \cdots & 0_{1 \times k} & 0 \\
1_2 & 0_{1 \times k} & 0_{1 \times k} & \cdots & 0_{1 \times k} & 0 \\
0_{1 \times k} & 1_2 & 0_{1 \times k} & \cdots & 0_{1 \times k} & 0 \\
0_{1 \times k} & 0_{1 \times k} & 1_2 & \cdots & 0_{1 \times k} & 0 \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
0_{1 \times k} & 0_{1 \times k} & 0_{1 \times k} & \cdots & 1_2 & 0
\end{bmatrix}
\begin{bmatrix}
\xi_t \\
\xi_{t|t} (1) \\
\xi_{t|t} (2) \\
\vdots \\
\xi_{t|t} (N) \\
\omega_t
\end{bmatrix},
\]

where \( D_{CPI} \) is a zero row vector of length \( N+k-1 \) with elements 1 and 2 equal to 1 and \( k=4 \). \( 1_n \) denotes the \( 1 \times n \) row vector with elements all equal to zero except the \( n \)-th one which is equal to one.
Estimation of forecaster panel model

Notes: $\ln \sigma^2_{c,t} \sim \mathcal{N}(\ln \sigma^2_{c,t-1}, .25)$, $\alpha(i) \sim \text{IG}(3,1)$, $\rho_c$, $\rho(i) \sim \text{Beta}(0.5,0.2)$, $\sigma_v(i) \sim \text{IG}(3,1)$

$\rho_c \sim \text{Beta}(0.5,0.2) \rightarrow$ Estimate of 0.99
US Survey of Professional Forecasters: Data overview

Selection of forecasters:
At least 32 forecasts → unbalanced panel of 51 forecasters

**Figure:** Time series summary of long-run CPI inflation expectations
Selection of forecasters

Figure: Time series of inflation expectations: mean(lhs) and median (rhs)

Note: Dashed vertical line indicates 2011Q1 before which we use 10Y and afterwards 5Y5Y expectations.
Selection of forecasters (cont)

**Figure:** Number of total and selected forecasters in the US SPF survey

- **Legend:**
  - Blue line: number of all forecasters
  - Orange line: number of selected forecasters
  - Black line: share (rhs)
Response of inflation expectations to shocks

Figure: Impulse response functions to one standard deviation shocks
Response of inflation to shocks

**Figure:** Impulse response functions to one standard deviation shocks
Extended panel estimation

Figure: Extended estimate of $\sigma_{c,t}$
Figure: Kalman gains for extended sample
Extended panel estimation (cont)

![Forecaster 15 (σ_z = 0.46, α = 0.59)](image1)

![Forecaster 19 (σ_z = 0.67, α = 0.74)](image2)

![Forecaster 23 (σ_z = 0.57, α = 1.77)](image3)

![Forecaster 27 (σ_z = 0.48, α = 0.89)](image4)

Figure: Historical decomposition of selected forecasters (extension)
Extended panel estimation (cont)

**Figure:** Historical decomposition of selected forecasters (extension)
Extended panel estimation (cont)

Figure: Historical decomposition of average inflation expectations (extension)
Stable US inflation expectations: Dec 2022

- More aggressive communication → lower $\sigma_{c,t}$?

Figure: Inflation path consistent with stable average long-term inflation expectations, $\sigma_{c,t}$ value from Dec 2015
References


Carvalho, Carlos, Stefano Eusepi, Emanuel Moench, and Bruce Preston (2020) “Anchored Inflation Expectations,” manuscript, The University of Melbourne.


