Managing the Risks of Inflation Expectation De-anchoring

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European Central Bank and IMF

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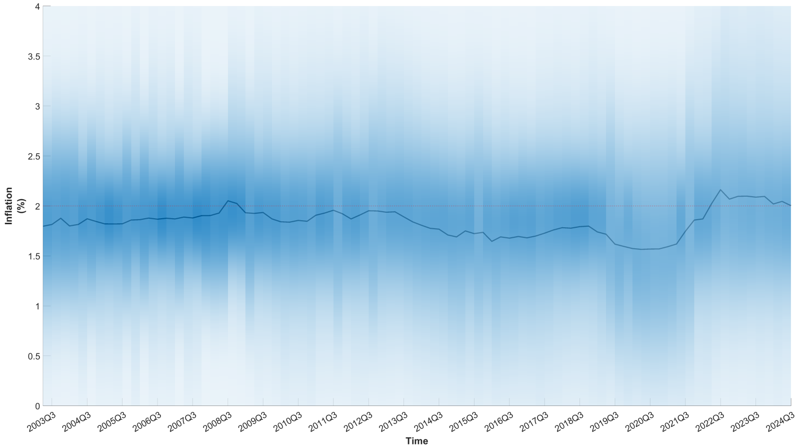
The views expressed are those of the authors and should not be attributed to the IMF, its Executive Board, or its management nor do they necessarily represent the view of ECB.

Aggregate probability distributions for longer-term inflation expectations

(annual percentage changes)

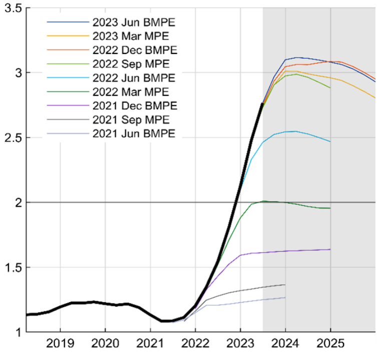


Sources: Authors' calculations, SPF.
Notes: The SPF asks respondents to report their point forecasts and to separately assign probabilities to different ranges of outcomes. This chart shows the bootstrapped pooled average probabilities assigned to different ranges of inflation outcomes in the longer term. Longer-term expectations refer to 5 years ahead responses.
Latest observations: 2024Q3.

Preview: Inflation De-Anchoring Risks Contained During Inflation Surge

Perceived inflation target in the projections from June 2021 to June 2023

(annual percentage changes)



Sources: Authors' calculations.

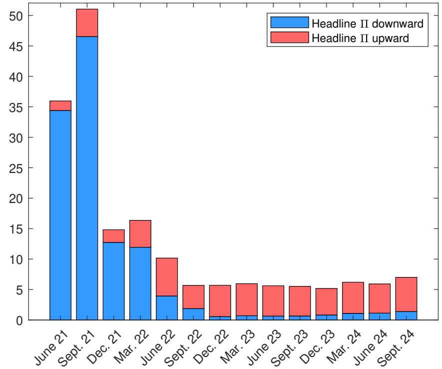
Notes: The charts show the perceived inflation target from June 2021 to June 2023. The perceived target is defined as:

$$\widehat{\pi^\star_t} = \rho \widehat{\pi^\star_{t-1}} + \varsigma(\pi_t - \widehat{\pi^\star_{t-1}}) + \varepsilon_t^{\pi^\star}$$

Latest observations: 2023Q2.

Risk of de-anchoring around the projections from June 2021 to June 2023

(percentages)



Sources: Authors' calculations.

Notes: The charts show the risk of de-anchoring for the projections from June 2021 to June 2023. The blue bars indicate downward, the yellow bars indicate upward de-anchoring. The model does not account for neither for the effective lower bound nor for non-standard measures.

Latest observations: 2023Q2.

Question: How to manage risks of de-anchoring?

- **Current paradigm:** Inflation expectation targeting central banks promise that inflation will be at target in the medium-term on average.
- **Longer-term inflation expectations**: are time-varying [in surveys].
- **Policy concern:** Prolonged one sided deviations of inflation from target can threaten the credibility and may lead to a de-anchoring of inflation expectations.

Our contributions:

- **Revisit optimal monetary policy** in presence of regime-switching expectations:
  - Exogenous switching: Similar to Clarida et al. (1999).
  - Endogenous switching: Trade-off of current welfare losses due to more reactive policy and welfare gains from increased credibility.
- **Propose a framework to model risk of inflation de-anchoring** derived from conditional stochastic simulations of a MS-DSGE around a baseline.

Literature Review

- **De-anchored inflation expectations:**
  - **European empirical evidence on de-anchoring:** Dovern et al. (2020); Corsello et al. (2021); Bahaj et al. (2023)
  - **Learning the inflation target:** Erceg and Levin (2003); Cogley and Sbordone (2008)
  - **Adaptive learning:** Marcet and Sargent (1989); Marcet and Nicolini (2003); Milani (2007, 2014); Slobodyan and Wouters (2012); Gáti (2023); Christiano et al. (2024)
  - **Adaptive learning of multiple models:** Carvalho et al. (2023)
- **Optimal monetary policy under learning and/or regime-switching:** Molnár and Santoro (2014); Woodford (2010); Adam and Woodford (2012); Choi and Foerster (2021); Gasteiger (2021); Gobbi et al. (2019); Nakata and Schmidt (2022)
- **Regime-switching DSGE:** Hamilton (1990); Kim (1994); Farmer et al. (2009); Bianchi (2012); Maih (2015); Foerster et al. (2016); Bianchi and Ilut (2017)

Outline

- Motivation & Question ✓
- Optimal Policy
- Model Overview
- Regime-Switching Kálmán Filter Learning
- Policy Applications & Conclusions

Optimal Policy - Notation

- The perceived inflation target follows a two-state Markov process. With two regimes: $i = h, \ell$. Where the **household's inflation target** is either $\pi^{*,h} = \pi^{*,CB}$ in the high credibility state, or $\pi^{*,\ell} \neq \pi^{*,CB}$ in the low credibility state.
- Constant probability case:

$$\text{Prob}(\pi^{*,h}_{t+1} = \pi^{*,h} | \pi^{*,h}_t = \pi^{*,h}) = p^h$$

$$\text{Prob}(\pi^{*,\ell}_{t+1} = \pi^{*,\ell} | \pi^{*,\ell}_t = \pi^{*,\ell}) = p^\ell$$

- We study optimal MP policy in the 3 equation NK model:

$$\widehat{\pi}_t = \kappa \widehat{y}_t + \beta E_t[\widehat{\pi}_{t+1}] + u_t$$

$$\widehat{y}_t = E_t[\widehat{y}_{t+1}] - \frac{1}{\sigma}(i_t - E_t[\widehat{\pi}_{t+1}] - r^n_t) + g_t$$

Optimal Policy - Constant Probability Case

- Discretion results in Clarida et al. (1999) for each regime:

$$i_t^h = \sigma E_t[\widehat{y}_{t+1}^h] + \left[1 + \frac{\kappa\beta\sigma}{\kappa^2+\lambda}\right] E[\widehat{\pi}_{t+1}^{CB}] + \frac{\sigma\kappa}{\kappa^2+\lambda} u_t + \sigma g_t$$

$$i_t^\ell = \sigma E_t[\widehat{y}_{t+1}^\ell] + \left[1 + \frac{\kappa\beta\sigma}{\kappa^2+\lambda}\right] E[\widehat{\pi}_{t+1}^{CB}] + \frac{\sigma\kappa}{\kappa^2+\lambda} u_t + \frac{(1-\beta)\sigma\kappa - 1}{\kappa^2+\lambda}(\pi^{*,\ell} - \pi^{*,CB}) + \sigma g_t$$

, where $\widehat{\pi}^{CB}$ is the inflation deviation from the CB's target.

- Commitment results in a smoothing rule that considers future switching:

$$\begin{aligned}
i_t^h = {} & r_t^n + \pi^{*,CB} + (1-p^h)(\pi^{*,\ell} - \pi^{*,CB}) \\
& + \left[p^h - \frac{\beta\kappa\sigma}{\lambda} A\right] E_t\left[\widehat{\pi}_{t+1}^h\right] + \left[(1-p^h) - \frac{\beta\kappa\sigma}{\lambda} B\right] E_t\left[\widehat{\pi}_{t+1}^\ell\right] \\
& + \frac{\beta\kappa\sigma}{\lambda} \left\{ p^h \left(E_t\left[\widehat{\pi}_{t+2}^h\right] - E_t\left[\widehat{\pi}_{t+1}^h\right]\right) + (1-p^h)\left(E_t\left[\widehat{\pi}_{t+2}^\ell\right] - E_t\left[\widehat{\pi}_{t+1}^\ell\right]\right) \right. \\
& \left. + C\left(E_t\left[\widehat{\pi}_{t+1}^h\right] - E_t\left[\widehat{\pi}_t^h\right]\right) + D\left(E_t\left[\widehat{\pi}_{t+1}^\ell\right] - E_t\left[\widehat{\pi}_t^\ell\right]\right) \right\} + \sigma g_t
\end{aligned}$$

Optimal Monetary Policy Summary

The optimal policy in the case of constant switching probabilities, leads to higher rates and a bias in due to the inflation target gap, the endogenous switching introduces a more aggressive response to surprises in inflation.

- Optimal policy under **constant regime switching probabilities**
  $\rightarrow$ Similar to Clarida et al. (1999), using formulation of Nakata and Schmidt (2022): Forceful leaning against de-anchoring.
- Optimal policy under **endogenous switching probabilities**
  $\rightarrow$ As in Woodford (2010); Adam and Woodford (2012) a more aggressive response to realized inflation.

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Definition of De-Anchoring - Based on Filtering of Regimes

Agents perceive the inflation target to be time-varying.

Our framework:

- Household forms regime-switching expectations about the inflation target.
- Taylor rule is defined and communicated with constant target:
  - **Anchored Regime:** Agents base their decisions on a constant inflation target.

$$\pi^* = 2.0\%$$

  - **De-Anchored Regime:** Agents base their decisions on a time varying inflation target.

$$\pi^* \longrightarrow \pi^* + \widehat{\pi^*}_t$$
$$\widehat{\pi^\star_t} = \rho \widehat{\pi^\star}_{t-1} + \varsigma(\pi_{t-1} - \widehat{\pi^\star}_{t-1}) + \varepsilon_t^{\pi^\star}$$

Once the probability of the de-anchored regime is higher we call expectations to be de-anchored.

Model - Regime-Switching NAWM

- The empirical exercise is based on the NAWM (Christoffel et al. ,2009) a workhorse macroeconomic DSGE model (Smets/Wouters plus open economy)
- Price and wage setting in the NAWM: Calvo with partial indexation scheme (Coenen, 2009)

$$P_{H,f,t} = \Pi_{H,t-1}^{\chi_H} \bar{\Pi}_t^{1-\chi_H} P_{H,f,t-1} \tag{1}$$

with $\chi_H = 0.42$ for domestic prices and $\chi_W = 0.63$ for wages.

$$\begin{aligned}\left(\widehat{\pi}_{H,t} - \widehat{\pi^*}_t\right) &= \frac{\beta}{1+\beta\chi_H} E_t\left[\widehat{\pi}_{H,t+1} - \widehat{\pi^*}_{t+1}\right] + \frac{\chi_H}{1+\beta\chi_H}\left(\widehat{\pi}_{t-1} - \widehat{\pi^*}_t\right) \\ &+ \frac{\beta\chi_H}{1+\beta\chi_H} E_t\left[\widehat{\pi^*}_{t+1} - \widehat{\pi^*}_t\right] + \frac{(1-\beta\xi_H)(1-\xi_H)}{\xi_H(1+\beta\chi_H)}\left(\widehat{mc}_t^H + \widehat{\varphi}_t^H\right)\end{aligned}$$

Comparison of Regimes

	Credible Regime	De-Anchored Regime
Inflation target	Fixed - Parameter	Time-varying - Endogenous state
Model parameters	Estimated	Estimated
# of endogenous states	115 + 1	115 + 2
# of shocks	21	21 + 1
# of observables	18	18
Steady state	Calibrated and estimated	Same as in the credible regime
Shock variance	Estimated	Estimated + calibrated

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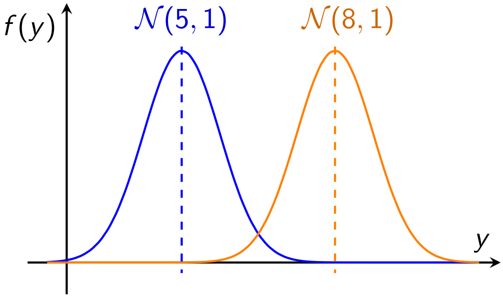
Intuition - Regime-Switching Kálmán Filter Learning

1. Agents **form expectations** given each regime
2. They have *a priori* beliefs about the regime probability - giving rise to a **mixture of normals**
3. **Structural shocks** and **data** realizes
4. Beliefs about the regime probabilities are **updated** - resulting in a *posterior* of regime probabilities.



Additional details on Regime-Switching Kálmán Filter.

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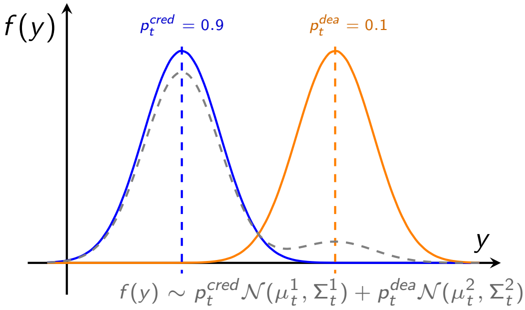

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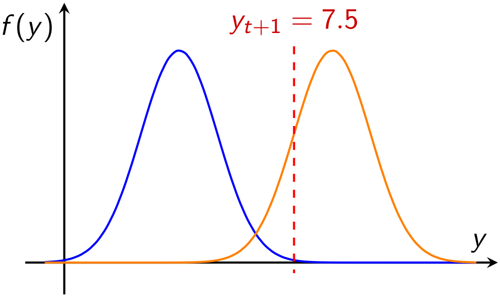

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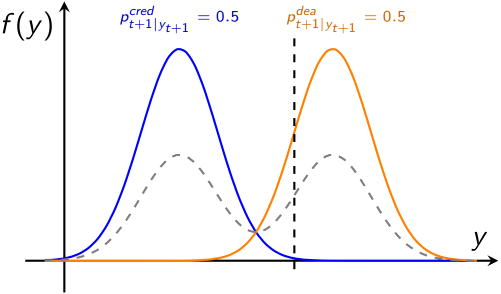
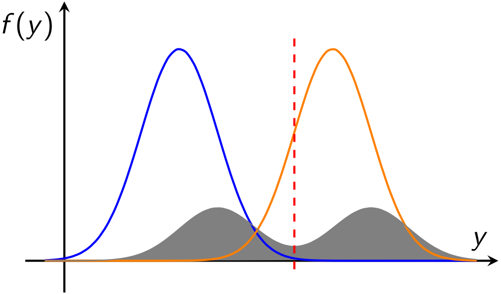


Additional details on Regime-Switching Kálmán Filter.

Intuition - Regime-Switching Kálmán Filter Learning

Time advances...

1. Agents form expectations
2. Shocks and data realizes
3. Regime probabilities are updated



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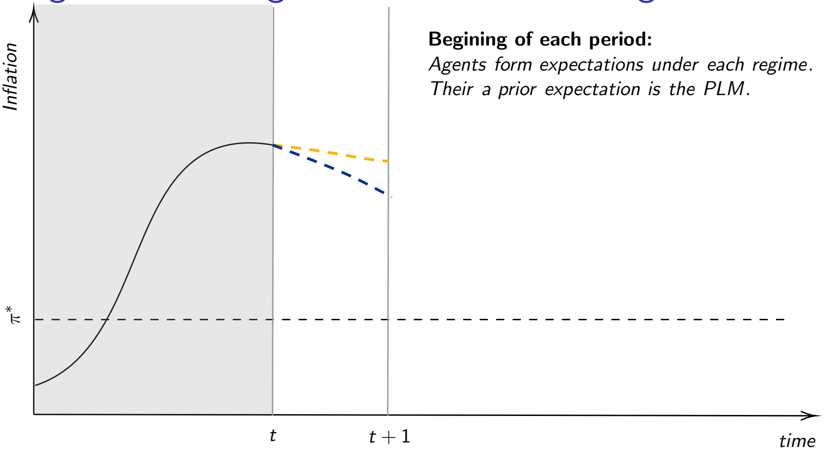
Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring

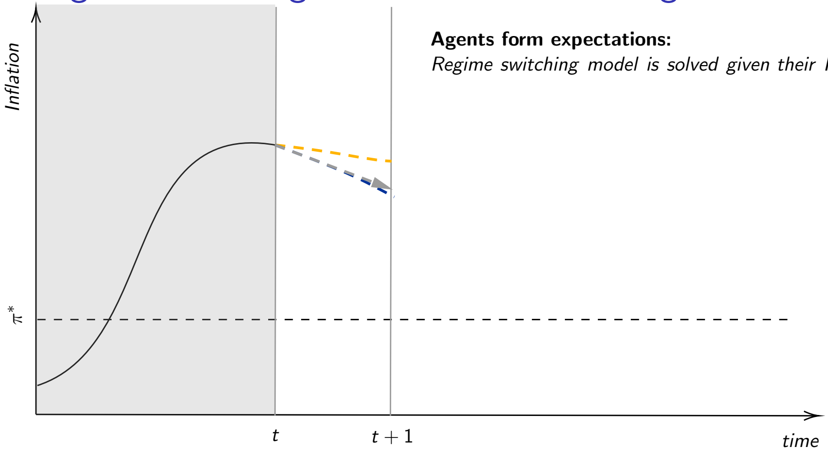


Begining of each period:
Agents form expectations under each regime.
Their a prior expectation is the PLM.

Posterior regime probabilities

p_t^{dea}	10%
p_t^{cred}	90%

Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring

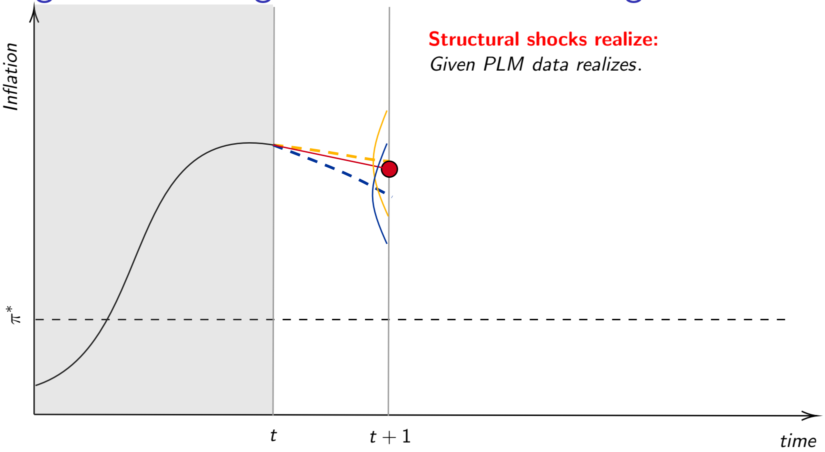


Agents form expectations:
Regime switching model is solved given their PLM.

Posterior regime probabilities

p_t^{dea}	10%
p_t^{cred}	90%

Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring

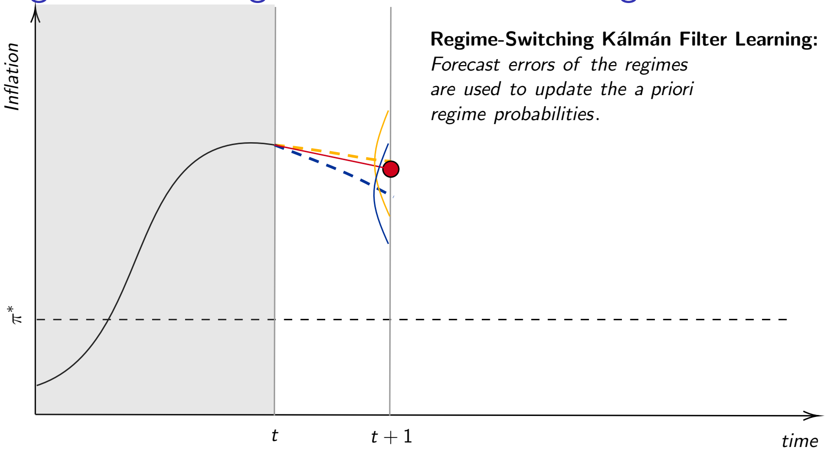


Structural shocks realize:
Given PLM data realizes.

Posterior regime probabilities

p_t^{dea}	10%
p_t^{cred}	90%

Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring

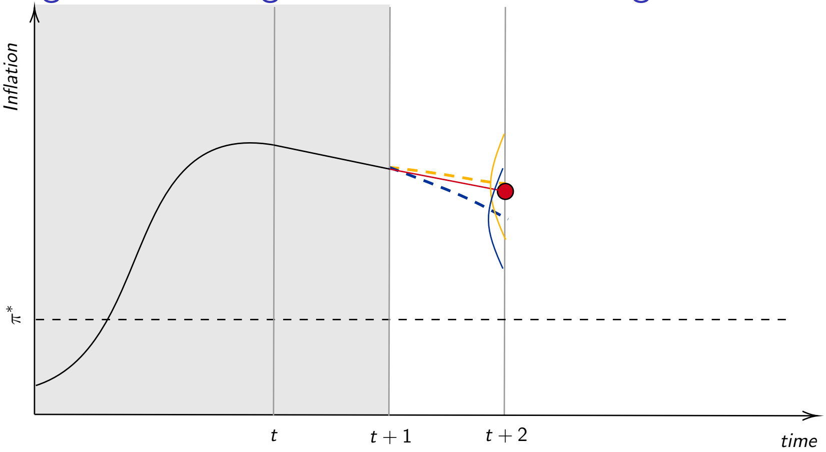


Regime-Switching Kálmán Filter Learning:
Forecast errors of the regimes are used to update the a priori regime probabilities.

Posterior regime probabilities

p_t^{dea}	10%	50%
p_t^{cred}	90%	50%

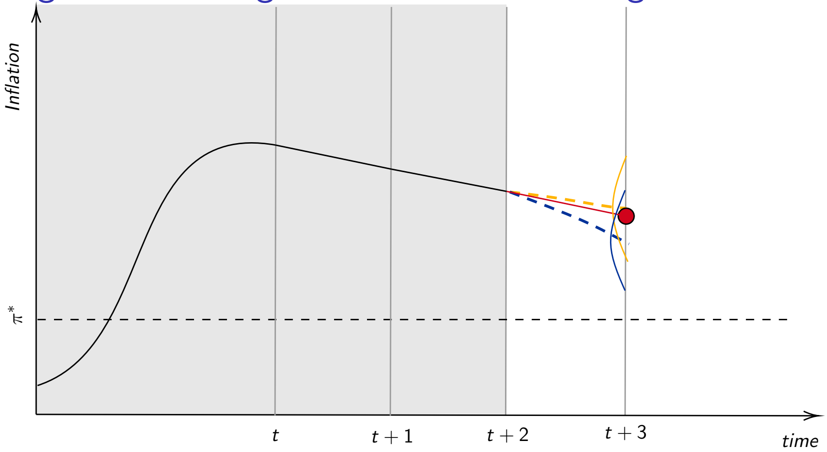
Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring



Regime probabilities

p_t^{dea}	10%	50%	75%
p_t^{cred}	90%	50%	25%

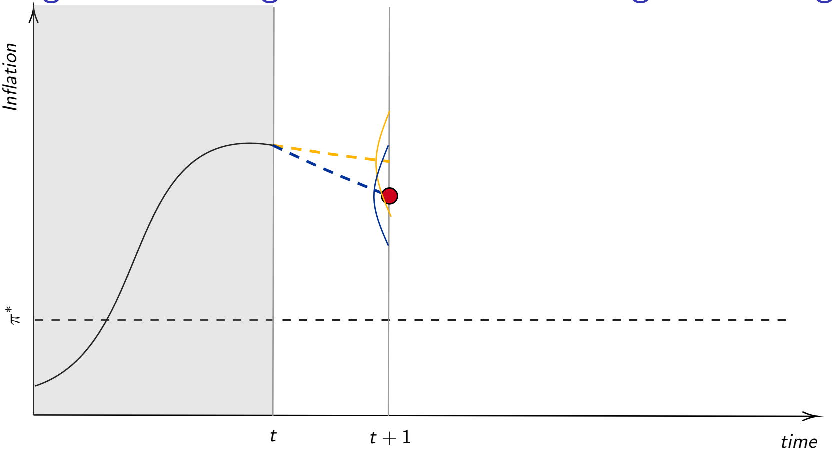
Intuition - Regime-Switching Kálmán Filter Learning: De-Anchoring



Posterior regime probabilities

p_t^{dea}	10%	50%	75%	90%
p_t^{cred}	90%	50%	25%	10%

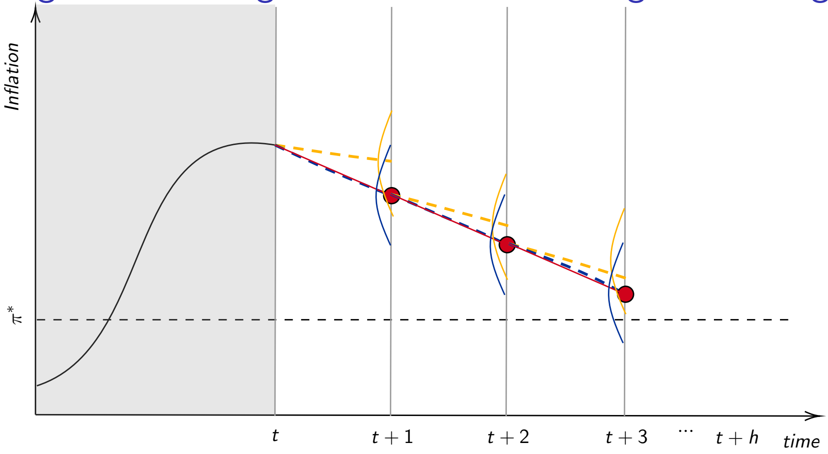
Intuition - Regime-Switching Kálmán Filter Learning: Anchoring



Posterior regime probabilities

p^{dea}	10%	5%
p^{cred}	90%	95%

Intuition - Regime-Switching Kálmán Filter Learning: Anchoring



Posterior regime probabilities

$p^{de-anchored}$	10%	5%	3%	1%
$p^{credible}$	90%	95%	97%	99%

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Real-Time Exercises on Euro Area Projections

Definition of exercise:

- Each quarter: take real-time database and projection.
- Filter the data plus forecast with RS-NAWM
- Conduct stochastic simulations around the baseline and filter for regime probabilities.
- Calculate de-anchoring risks.

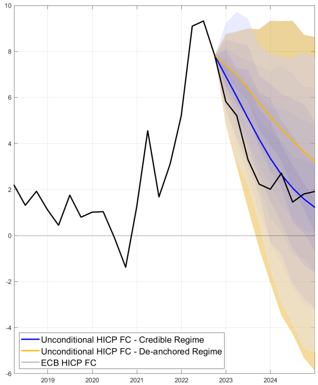
Definition of de-anchoring:

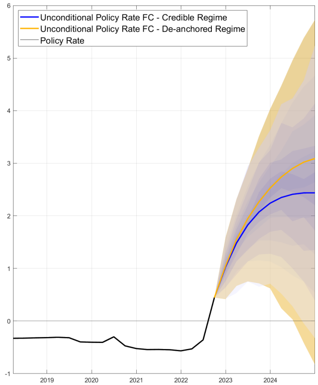
- Filtered regime probability of de-anchored regime exceeds 50%.

Definition of the risk of de-anchoring:

- The share de-anchored simulation paths around a projection.

Uncertainty around the September 2022 forecast inflation projections
(year-on-year percentage points)

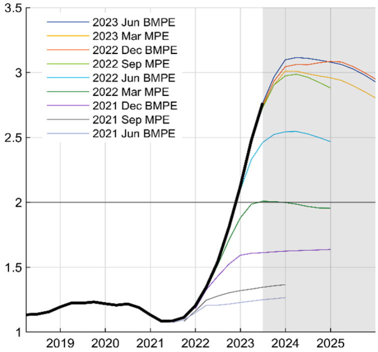




Sources: Authors' calculations.
Notes: The chart shows the unconditional forecasts, and the uncertainty bands of the conditional forecast of the RS-NAWM for inflation and the policy rate conditioning on the ECB's 2022 September MPE projections. The blue line shows the unconditional forecast of the credible regime. The yellow line shows the unconditional forecast of the de-anchored regime. The shaded areas correspond to the quantiles of the respective regimes from the RS-NAWM, where a path is considered de-anchored if the filtered probability of the de-anchored regime exceeds 50% over the evaluation horizon of 9 quarters.
Latest observations: 2022Q2.

Real-Time Exercises on Euro Area Projections

Perceived inflation target in the projections from June 2021 to June 2023
(annual percentage changes)

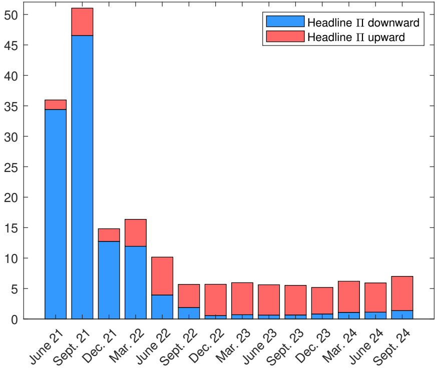


Sources: Authors' calculations.
Notes: The charts show the perceived inflation target from June 2021 to June 2023. The perceived target is defined as:

$$\widehat{\pi^\star_t} = \rho\widehat{\pi^\star_{t-1}} + \varsigma(\pi_t - \widehat{\pi^\star_{t-1}}) + \varepsilon^{\pi^\star}_t$$

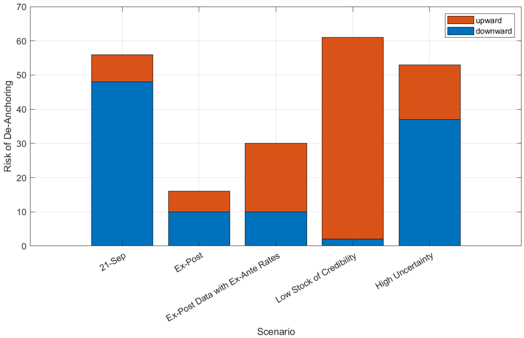
Latest observations: 2023Q2.

Risk of de-anchoring around the projections from June 2021 to June 2023
(percentages)



Sources: Authors' calculations.
Notes: The charts show the risk of de-anchoring for the projections from June 2021 to June 2023. The blue bars indicate downward, the yellow bars indicate upward de-anchoring. The model does not account for neither for the effective lower bound nor for non-standard measures.
Latest observations: 2023Q2.

Drivers of De-anchoring



- **Sep 21:** 'before the inflation surge': very flat expected inflation, low inflation period implied low perceived target.
- **Ex-post:** Re-evaluating the Sept 21 exercise with the ex-post realization of data.
- **Rate-setting:** ex-post data realization, but expected policy path from original Sep 21 exercise.
- **Stock of credibility:** assuming that the inflation surge had been preceded by a high inflation period (average inflation 2.9)
- **High uncertainty:** revisit the ex-post analysis, but assuming a higher shock variance.

Conclusions

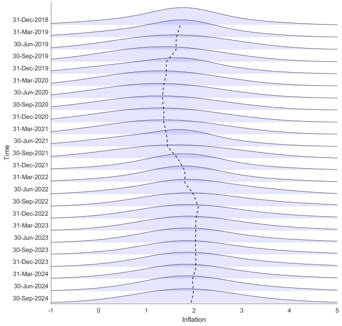
- We develop a monetary policy framework in which the central bank internalizes the risk of inflation expectations de-anchoring, modeled via endogenous regime switching in a medium-scale DSGE model.
- We derive the optimal monetary policy under de-anchoring risk: the central bank balances the welfare cost of stronger inflation responses with the benefit of maintaining credibility.
- We propose a model-based real-time indicator to assess the risk of de-anchoring, complementing survey- and market-based measures.
- Our approach enables policy scenario analysis and counterfactuals to evaluate how alternative strategies affect credibility and expectations.

Thank you for your attention!

BACKGROUND SLIDES

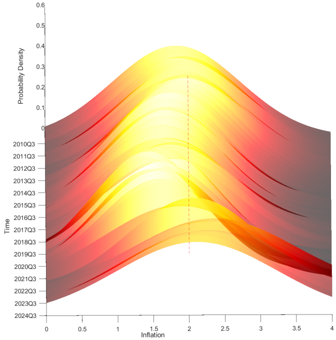
Longer-term Inflation Expectations in the Euro Area

Aggregate probability distributions for longer-term inflation expectations
(annual percentage changes)



Sources: Authors' calculations, SPF.
Notes: The SPF asks respondents to report their point forecasts and to separately assign probabilities to different ranges of outcomes. This chart shows the bootstrapped pooled average probabilities assigned to different ranges of inflation outcomes in the longer term. Longer-term expectations refer to 5 years ahead responses.
Latest observations: 2024Q3.

De-anchored component of longer-term inflation expectations
(annual percentage changes)



Sources: Authors' calculations.
Notes: The charts show the de-anchored component of the Gaussian Mixture Model fitted to the long-term inflation expectations according to the ECB's SPF. The blue bars indicate downward, the yellow bars indicate upward de-anchoring. The model does not account for neither for the effective lower bound nor for non-standard measures.
Latest observations: 2023Q4.

$$
\begin{aligned}
\widehat{w}_t \;=\;& \frac{\beta}{1+\beta}\,\mathrm{E}_t\left[\widehat{w}_{t+1}\right] + \frac{1}{1+\beta}\,\widehat{w}_{t-1} + \frac{\beta}{1+\beta}\,\mathrm{E}_t\left[\widehat{\pi}_{C,t+1}\right] \qquad \text{(A.}\\
& - \frac{1+\beta\chi_W}{1+\beta}\,\widehat{\pi}_{C,t} + \frac{\chi_W}{1+\beta}\,\widehat{\pi}_{C,t-1} - \frac{\beta(1-\chi_W)}{1+\beta}\,\mathrm{E}_t\left[\widehat{\bar{\pi}}_{C,t+1}\right]\\
& + \frac{1-\chi_W}{1+\beta}\,\widehat{\bar{\pi}}_{C,t} - \frac{\left(1-\beta\xi_W\right)\left(1-\xi_W\right)}{\left(1+\beta\right)\xi_W\,\Psi(\varphi^W,\zeta)}\left(\widehat{w}_t^\tau - \widehat{mrs}_t - \widehat{\varphi}_t^W\right),
\end{aligned}
$$

with

$$
\widehat{\bar{\pi}}_t = \widehat{\pi_t^*}
$$

Regime-Switching Kálmán Filter Learning Technical Details - Notation

Object of interest: The filtered regime probability in period t

- State space representation of regime i:

$$x_t^i = \mathbf{A^i} x_{t-1}^i + \mathbf{R^i} \varepsilon_t,$$
$$y_t = p_t^i \mathbf{H^i} x_t^i$$
$$\varepsilon_t \sim \mathcal{N}(0, I)$$

- Regime probabilities: p_t^i

- Regime transition matrix:

$$Z = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$$

- Equivalently:

$$y_t \sim \sum_i p_t^i \cdot \mathcal{N}(\mu_t^i, \Sigma_t^i)$$

, where $\mu_t^i = \mathbf{H^i A^i} x_{t-1}^i ; \Sigma_t^i = (\mathbf{R^i})^T \mathbf{R^i}$.

- Regime probabilities: p_t^i

- Regime transition matrix:

$$Z = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$$

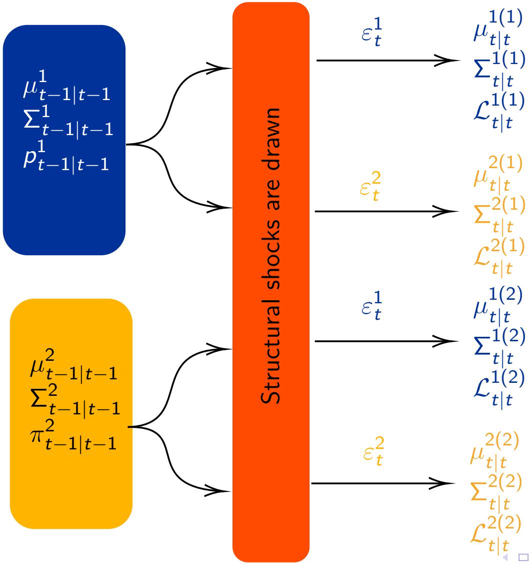
Stochastic Simulation with RSKF Learning - I. Initial Conditions

$\mu^1_{t-1|t-1}$
$\Sigma^1_{t-1|t-1}$
$p^1_{t-1|t-1}$

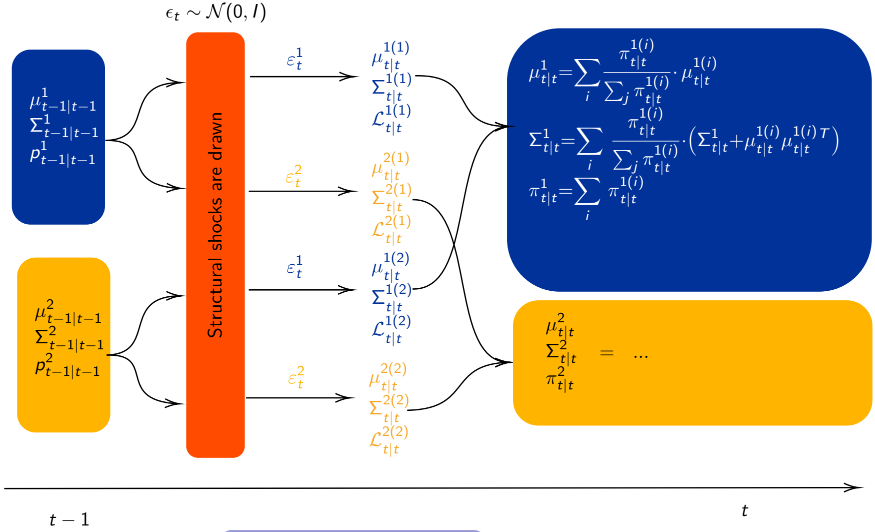
$\mu^2_{t-1|t-1}$
$\Sigma^2_{t-1|t-1}$
$\pi^2_{t-1|t-1}$

Stochastic Simulation with RSKF Learning - II. Shocks, Prediction, Update

$$\epsilon_t \sim \mathcal{N}(0, I)$$



$$Z = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \qquad \pi_{t|t}^{j(i)} = \frac{\mathcal{L}_{t|t}^{j(i)} \cdot z_{ij} \cdot {\pi^i}_{t-1|t-1}}{\sum_j \sum_i \mathcal{L}_{t|t}^{j(i)} \cdot z_{ij} \cdot {\pi^i}_{t-1|t-1}}$$



Source: Authors' illustration. Jump back to Regime-Switching Kálmán Filter overview.

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