Inflation (de-)anchoring in the euro area

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European Economic Association
26 August 2024

Note: The views expressed in this presentation do not necessarily reflect those of the European Central Bank, Banque de France, National Bank of Belgium or the Eurosystem.

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Motivation: Why look at inflation expectations?

- Dynamic IS curve (Fisher equation: real rate = nominal rate - inflation expectation)
- New Keynesian Phillips curve: price stickiness (and monopolistic competition) implies forward-lookingness in price setting

"The firm anchoring of inflation expectations is critical under any circumstances, as it ensures that temporary movements in inflation do not feed into wages and prices and hence become permanent." - ***Mario Draghi, 21 November 2014***

"The risks to the medium-term inflation outlook include [...] inflation expectations rising above our target [...]." - ***Christine Lagarde, 21 July 2022***

- A de-anchoring of (long-term) inflation expectations might reflect credibility issues related to the willingness and/or capacity of the central bank to deliver on its price stability objective

Comprehensive framework for assessing (de-)anchoring

- The Eurosystem's Expert Group on inflation expectations (ECB, 2021) highlighted "the need for a comprehensive framework for assessing (un)anchoring"
- Issues related to the level of inflation expectations:
  - Market-based measures contain inflation risk premia
  - Surveys gauge "genuine" expectations, but also have issues
- Overall, the workstream concludes that in the period since the global financial and European debt crises, longer-term inflation expectations in the euro area have become less well anchored

Literature review

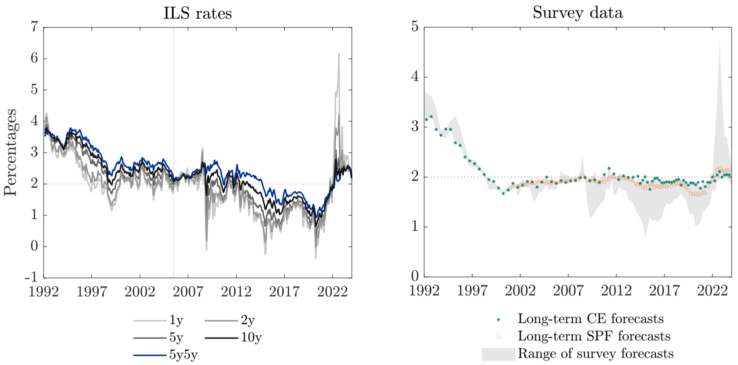
- **Beechey et al. (2011)** find that long-run inflation expectations are more firmly anchored in the euro area than in the United States (pre-2010)
- **Hördahl and Tristani (2014)**'s results indicate that long-term inflation expectations extracted from bond prices have remained remarkably stable at the peak of the financial crisis and throughout the Great Recession
- **Łyziak and Paloviita (2017)** find that longer-term inflation expectations have become somewhat more sensitive to shorter-term ones and to actual inflation in the 2010s
- **Grishchenko et al. (2019)** suggest that, following the Great Recession, inflation anchoring improved in the United States, while mild de-anchoring occurred in the euro area
- **Corsello et al. (2021)** suggest that long-term inflation expectations have de-anchored from the ECB's inflation aim following the 2013-14 disinflation (data up to 2019)
- **Cecchetti et al. (2022)** find a quite volatile medium-term risk-adjusted expected inflation, falling to 0.8% in 2016 and being below 1% from mid-2019 to early 2021
- **Boeckx et al. (2024)** develop a macro-finance model providing estimates of long-term inflation expectations that come close to those reported below, and they carry out a structural decomposition of ILS rates

What we do

- Apply the shifting endpoint term structure model of Bauer and Rudebusch (2020) to euro area market-based measures of inflation compensation
- Introduce survey inflation forecasts as in Kim and Orphanides (2012), speaking to a "comprehensive framework"
- Look at π_t^* - an aggregate measure of long-term inflation expectations - as main indicator of potential de-anchoring (from the ECB's inflation target)
- Decompose market-based measures into "genuine" inflation expectations and inflation risk premia: focus on the 1y2y, 1y4y and 5y5y ILS rates, speaking to the (various interpretation of the) "medium-term" inflation objective

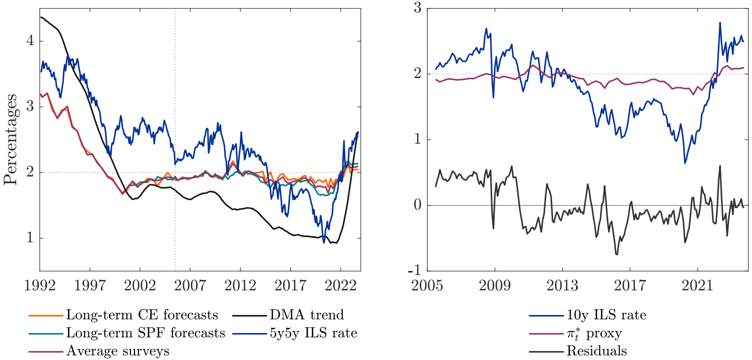
What we find

- Estimates of π_t^* appear broadly anchored, as well as the expectations components of the 5y5y and 1y4y ILS rates...
- ... but the expectations component of the 1y2y ILS rate shows signs of de-anchoring (also for models with fixed endpoint, with or without surveys)
- Estimates of inflation expectations are more volatile (and estimates of inflation risk premia are less volatile) for medium to long-term horizons for models based on ILS rates with a π_t^* (compared to models with a fixed endpoint)...
- ... but surveys - which help to estimate π_t^* by pinning down a tricky model parameter - flatten estimates of π_t^*
- Estimates of π_t^* are much above 2% in the early 1990s, with however fast convergence to levels below 2% by the end of the decade
- There is no evidence of regime shift in the dynamics of π_t^* during COVID-19



ILS rates and inflation survey forecasts. ILS rates are continuously compounded and adjusted for the indexation lag as in Camba-Méndez and Werner (2017), and backcasted before 2005 as in Burban and Schupp (2023) as highlighted by the dotted vertical line. The range of survey forecasts comprises forecasts from Consensus Economics (CE) and the ECB's SPF. "Long-term SPF forecasts" refer to average point forecasts for the annual inflation rate in the fourth or the fifth calendar year. "Long-term CE forecasts" refer to average point forecasts for the average annual inflation in 6 to 10 years time.

Many potential trend inflation proxies ($\hat{\pi}_t^*$)



Inflation trend proxies and cointegration residuals. On the left panel, "DMA" stands for discounted moving average (Cieslak and Povala, 2015). The 5y5y ILS rate is observed as of June 2005 (right of vertical dashed line) and backcasted to 1992 based on Burban and Schupp (2023). On the right panel, cointegration residuals come from a regression of the 10y ILS rate on the observed π_t^* proxy taken as the average of long-term SPF and CE forecasts and the CE fifth calendar year forecasts.

Standard affine term structure model with fixed endpoint

- Short-term rate is affine in the observed principal components $\mathcal{P}_t$:

$$\pi_t = \rho_0 + \rho_1 \mathcal{P}_t, \quad (1)$$

- The principal components $\mathcal{P}$ follow a VAR(1) under the $\mathbb{P}$- and $\mathbb{Q}$-probability measure:

$$\mathcal{P}_t = \mathcal{K}_0^{\mathbb{P}} + \mathcal{K}_1^{\mathbb{P}} \mathcal{P}_{t-1} + \epsilon_t^{\mathbb{P}}, \quad \epsilon_t^{\mathbb{P}} \sim N(0, \Sigma_{\mathcal{P}}) \quad (2)$$

$$\mathcal{P}_t = \mathcal{K}_0^{\mathbb{Q}} + \mathcal{K}_1^{\mathbb{Q}} \mathcal{P}_{t-1} + \epsilon_t^{\mathbb{Q}}, \quad \epsilon_t^{\mathbb{Q}} \sim N(0, \Sigma_{\mathcal{P}}) \quad (3)$$

,

hence also the cross-section of ILS rates, Π_t, is affine in $\mathcal{P}$:

$$\Pi_t = A_{\mathcal{P}} + B_{\mathcal{P}} \mathcal{P}_t + \mu_t, \quad (4)$$

where $A_{\mathcal{P}}$ and $B_{\mathcal{P}}$ depend on the $\mathbb{Q}$-parameters, ρ_0, ρ_1, and $\Sigma_{\mathcal{P}}$.

- Estimation in two steps:
  1. Estimate $\mathcal{K}_0^{\mathbb{P}}$ and $\mathcal{K}_1^{\mathbb{P}}$ from (2) by OLS
  2. Maximise the joint likelihood of (2)-(4) given $\mathcal{K}_0^{\mathbb{P}}$ and $\mathcal{K}_1^{\mathbb{P}}$

Term structure model with a shifting endpoint

- Following Bauer and Rudebusch (2020), a time-varying π_t^* is introduced as an *unobserved* common trend for factors $\mathcal{P}_t$:

$$\mathcal{P}_t = \bar{\mathcal{P}} + \gamma\pi_t^* + \tilde{\mathcal{P}}_t, \tag{5}$$
$$\pi_t^* = \pi_{t-1}^* + \eta_t^{\mathbb{P}}, \quad \eta_t^{\mathbb{P}} \sim i.i.d.\ N(0,\sigma_\eta^2), \tag{6}$$
$$\tilde{\mathcal{P}}_t = \Phi\tilde{\mathcal{P}}_{t-1} + \tilde{\epsilon}_{t,\tilde{\mathcal{P}}}^{\mathbb{P}}, \quad \tilde{\epsilon}_{t,\tilde{\mathcal{P}}}^{\mathbb{P}} \sim N(0,\tilde{\Sigma}_{\mathcal{P}}). \tag{7}$$

- $\mathcal{P}_t$ has innovations $\gamma\eta_t^{\mathbb{P}} + \tilde{\epsilon}_{t,\tilde{\mathcal{P}}}^{\mathbb{P}}$, with covariance $\Sigma_{\mathcal{P}} = \gamma\gamma'\sigma_\eta^2 + \tilde{\Sigma}_{\mathcal{P}}$
- For identification, impose that the trend π_t^* is the $\mathbb{P}$-measure endpoint level of the short-term inflation rate π_t:

$$\lim_{h\to\infty} E_t^{\mathbb{P}}[\pi_{t+h}] \equiv \pi_t^* = \rho_0 + \rho_1 \lim_{h\to\infty} E_t^{\mathbb{P}}[\mathcal{P}_{t+h}]$$
$$= \underbrace{\rho_0 + \rho_1\bar{\mathcal{P}}}_{=0} + \underbrace{\rho_1\gamma}_{=1}\pi_t^* \tag{8}$$

Term structure model with a shifting endpoint

- Recast (5) - (7) into a standard VAR by defining $Z_t = (\pi_t^*, \mathcal{P}_t)'$:

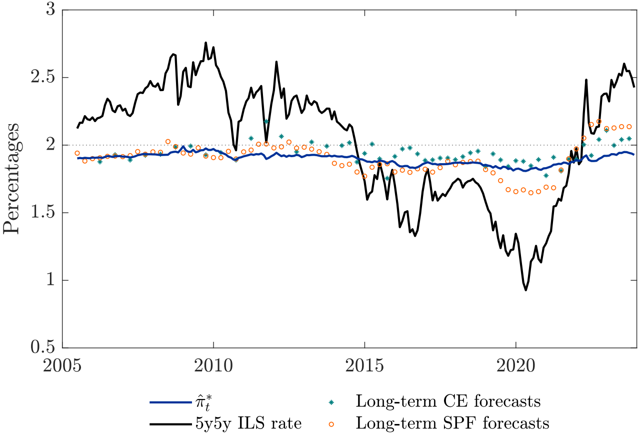
$$Z_t = \mu_Z + \Phi_Z Z_{t-1} + v_t \quad (9)$$

- π_t^* is unspanned by ILS rates (since the short-term rate equation remains as in (1) and the $\mathbb{Q}$-dynamics of $\mathcal{P}$ are stationary as in (3)):

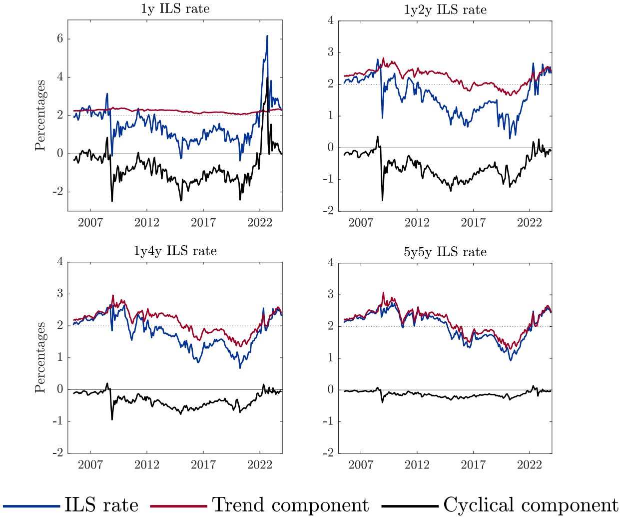
$$\Pi_t = A_{\mathcal{P}} + \begin{pmatrix} 0 & \\ \vdots & B_{\mathcal{P}} \\ 0 & \end{pmatrix} Z_t + \mu_t^Z, \quad (10)$$

- Kalman filter estimation, with additional measurement equations to align model-implied forecasts (expectations components) with survey forecasts (up to some - autocorrelated - survey measurement error)
  - ECB's Survey of Professional Forecasters: 2^{nd} calendar year, 1y, 2y, 4^{th}-5^{th} calendar year
  - Consensus Economics: 2^{nd} calendar year, 3^{rd} calendar year, 4^{th} calendar year, 5^{th} calendar year, 6^{th}-10^{th} calendar year

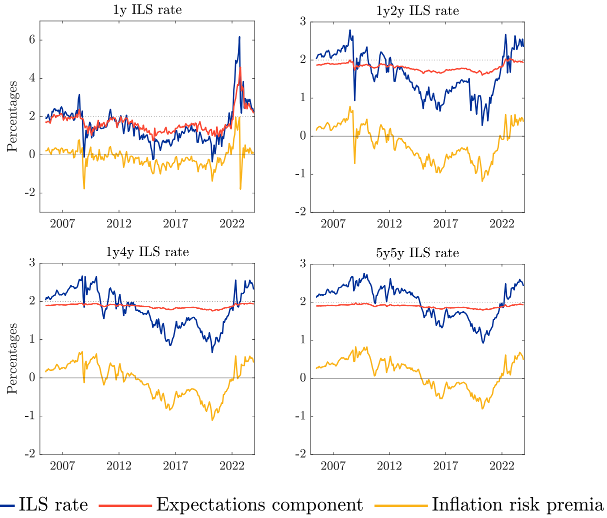
π_t^* estimate



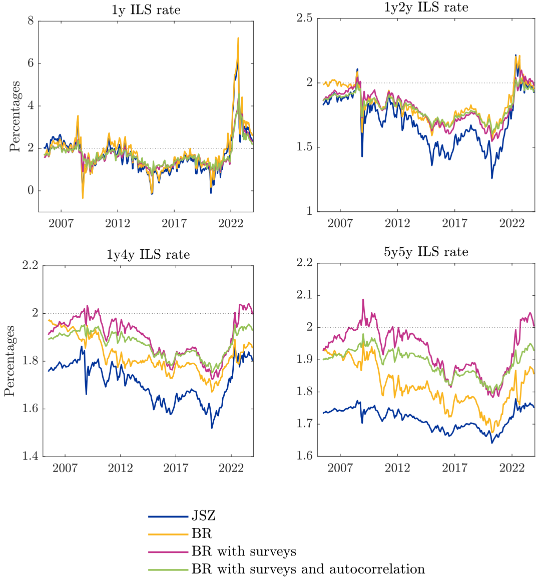
Trend and cyclical components in ILS rates



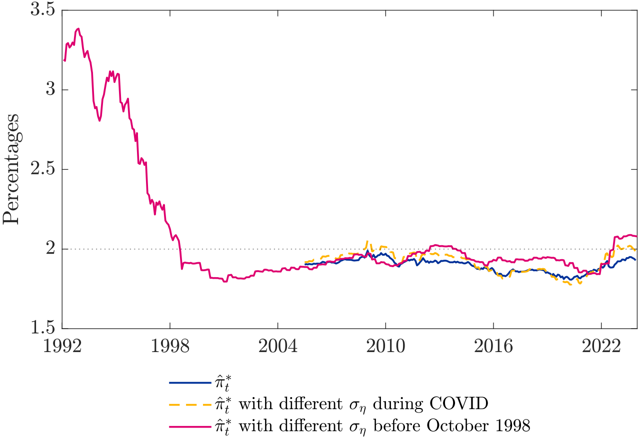
Inflation expectations components and inflation risk premia



Expectations components: different model specifications



Estimated π_t^* with regime shifts



Conclusion and future research

Conclusion

- Long-term inflation expectations have been well-anchored with the ECB's inflation objective...
- ... with however some tentative signs of de-anchoring up to the 1y2y horizon
- No evidence of regime shift during COVID-19
- Fast convergence of π_t^* estimates in the 1990s to below 2%

Future research

- Include consumer expectations in the model
- Consider the dispersion of individual forecasts
- Application to different jurisdictions (US, UK, JP, BR, ZA, ...)
- More thorough investigation of regime shifts

Thank you for your attention!

Evidence of cointegration (2005-2023)

	Avg. surveys	CE	SPF	DMA
Constant	-0.061***	-0.050***	-0.049***	0.002
	(0.006)	(0.012)	(0.004)	(0.002)
π^* proxy	4.135***	3.517***	3.557***	1.192***
	(0.326)	(0.590)	(0.237)	(0.155)
R^2	60	27	73	66
$ADF_{OLSresidual}$	-4.30***	-3.51***	-3.15***	-3.20***
$PP_{OLSresidual}$	-3.72***	-2.97***	-3.91***	-2.89***
$ADF_{DOLSresidual}$	-2.01**	-1.89*	-1.64*	-3.08***
$PP_{DOLSresidual}$	-2.00**	-1.95**	-1.65*	-3.11***
Johansen trace $r = 0$	17.22**	21.92***	12.94	28.86***
Johansen trace $r = 1$	1.30	1.33	1.75	2.99*
Johansen eigenvalue $r = 0$	15.92**	20.59***	11.19	25.87***
Johansen eigenvalue $r = 1$	1.30	1.33	1.75	2.99*

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Cointegration regressions and tests based on 10y ILS rates. "DMA" stands for discounted moving average (Cieslak and Povala, 2015). Coefficients are based on regressions with Newey-West standard errors (using four lags) in parentheses. For the cointegration residuals from regressions estimated by OLS and dynamic OLS (DOLS), the second panel reports standard deviations, Augmented Dickey-Fuller (ADF) and Pillips-Perron (PP) unit root test statistics. DOLS regressions include four leads and lags of the first difference of the 10y ILS rate and observed π_t^* proxy. The table also reports the Johansen trace and eigenvalue statistics, which tests whether the cointegration rank (r) among the ILS rates and π_t^* proxy is 0/1 against the alternative that it exceeds 0/1 (trace) or it equals 1/2 (eigenvalue). The number of lags for ADF and Johansen tests is selected based on the AIC. The data are observed at monthly frequency.

Evidence of the π^**proxy* being unspanned

	(1) Avg. surveys	(2) CE	(3) SPF	(4) DMA
Main sample, 2005-2023	62%	31%	77%	68%
Subsample, 2005-2019	49%	20%	72%	83%
Extended sample, 1992-2023	60%	53%		81%

Spanning tests as in Joslin et al. (2014). The table reports adjusted R^2 from regressions of observed π_t^* proxies on the first three principal components of ILS rates. The data are observed at monthly frequency. "Avg. surveys" refers to the average of long-term SPF and CE forecasts and the CE fifth calendar year forecasts.

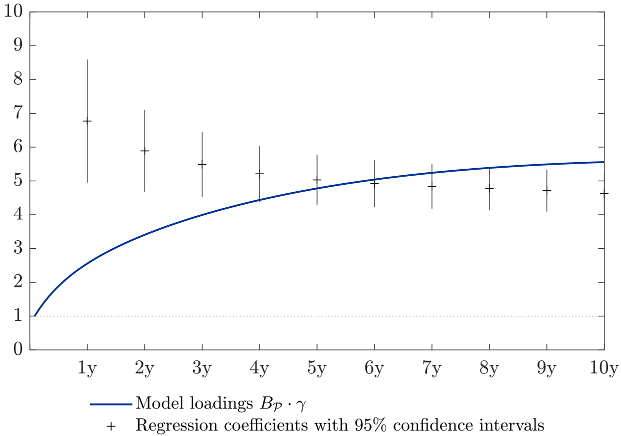
Evidence of the π^**proxy* being unspanned

	(1) ILS rates only	(2) Avg. surveys	(3) CE	(4) SPF	(5) DMA
Main sample, 2005-2023					
Constant	-0.003*	0.013	0.006	0.013	-0.003
	(0.002)	(0.009)	(0.008)	(0.009)	(0.002)
$PC1$	0.009	0.041*	0.018	0.062**	0.008
	(0.017)	(0.023)	(0.017)	(0.029)	(0.039)
$PC2$	-0.156**	-0.180**	-0.164**	-0.183***	-0.154**
	(0.065)	(0.071)	(0.067)	(0.070)	(0.077)
$PC3$	-0.009	0.159	0.075	0.221	-0.012
	(0.312)	(0.304)	(0.327)	(0.280)	(0.299)
π^* proxy		-0.932*	-0.493	-1.044*	0.008
		(0.525)	(0.417)	(0.536)	(0.252)
		[0.098]	[0.189]	[0.058]	[0.477]
R^2	3.98	6.09	4.37	6.70	3.53

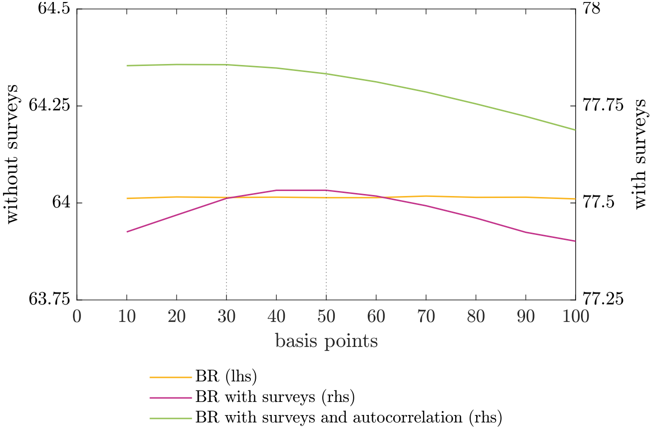
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Spanning tests based on one-period realised quarterly excess returns regressions.
Regressions of realised quarterly excess returns averaged across 2 to 10-year maturities. The three first principal components describing the term structure of the ILS rates are used as predictors. For each maturity, we compare the ILS-only specification (column 1) and the same specification but adding an observed π_t^* proxy (columns 2 to 5). Regression coefficients are displayed along with Newey-West standard errors (four lags) in parentheses (with significance levels highlighted with stars), and small-sample (one-sided) p-values for the observed π_t^* proxy obtained with the bootstrap method of **?** in brackets. The data are observed at monthly frequency.

ILS rates loadings on π_t^*

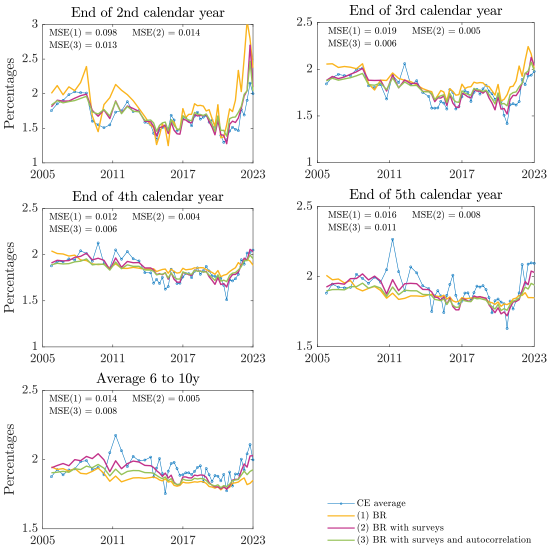


Average log-likelihoods as a function of σ_η

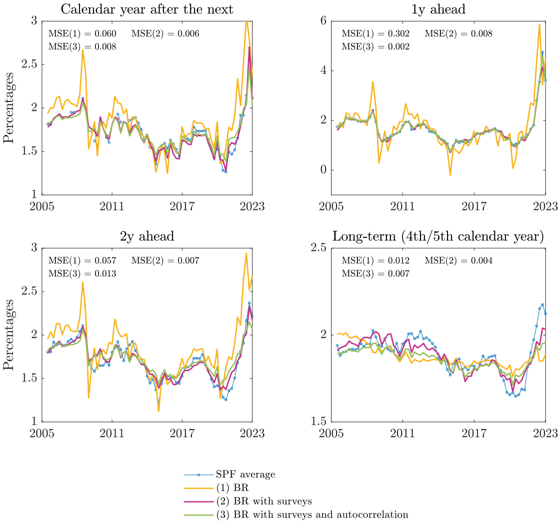


Note: σ_η **is expressed as standard deviation per century.**

Fit of Consensus Economics survey forecasts



Fit of SPF forecasts



ILS rates fitting errors

	1y	2y	3y	4y	5y	6y	7y	8y	9y	10y	avg
$\tilde{\Omega}$ full	1.15	3.38	1.43	1.30	1.77	1.77	1.27	0.68	1.06	2.02	1.58
$\tilde{\Omega}$ diag	1.20	3.38	1.41	1.29	1.76	1.75	1.27	0.80	1.25	2.15	1.63

ILS rates fitting errors. The table reports root mean squared fitting errors. "$\tilde{\Omega}$ diag" refers to the restriction imposing that $\tilde{\Omega}$ is a diagonal matrix. "$\tilde{\Omega}$ full" refers to a full $\tilde{\Omega}$ matrix.

Exclusion restriction tests

Restriction	Log-llk	Pval	AIC	BIC
Φ full	17213.45	-	-34384.91	-34313.46
$\phi_{2,1} = 0$	17202.92	0	-34365.84	-34297.79
$\phi_{2,1} = \phi_{3,2} = 0$	17188.51	0	-34339.03	-34274.38
$\phi_{2,1} = \phi_{3,2} = \phi_{1,2} = 0$	17183.18	0.1%	-34330.35	-34269.11

Exclusion restriction tests. Likelihood ratio tests are carried out for each additional exclusion restriction. ϕ refers to elements populating Φ with the first subscript referencing the line, and the second referencing the column. "Pval" stands for p-value.

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