Online Appendix to

Monetary Policy, Information and Country Risk Shocks in the Euro Area

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November 8, 2024

Abstract

This online appendix contains model derivations, details on the data used, and additional results for the paper 'Monetary Policy, Information and Country Risk Shocks in the Euro Area'.

JEL classification: E32, E52, E58

Keywords: Monetary policy, euro area, information effects, unconventional monetary policy

Contents

A A model of information effects with high and low noise 2

B Data 13

B.1 On core inflation 15

B.2 On industrial production 16

C Factor extraction 17

D Target factor loadings 20

E VSTOXX in periods of high volatility 21

F Information effects – Additional tables 23

G Rolling subsamples for IRFs 28

H Rolling subsamples for IRFs Altavilla et al. (2019) 33

I A comparison with Kerssenfischer (2022) 38

J Variance decomposition – Additional tables 39

K List of 10 largest surprises in identified factor series 41

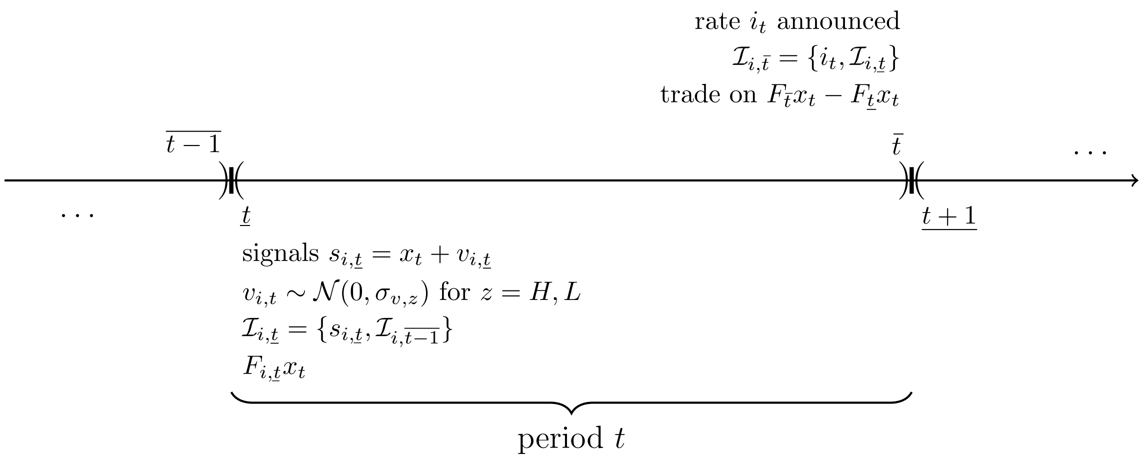
K.1 Target factor 43

K.2 Forward guidance factor 44

K.3 Quantitative easing factor 45

K.4 Asymmetric country risk factor 46

Figure A.1: The Information Flow



Note: Each period t has a beginning $\underline{t}$ and an end $\bar{t}$. At $\underline{t}$ agents (both private and central bank) receive noisy signals $s_{i,\underline{t}}$ about the economy x_t, and update their forecasts $F_{i,\underline{t}}x_t$ based on their information set $\mathcal{I}_{i,\underline{t}}$. At $\bar{t}$ the central bank announces the policy rate i_t based on its forecast $F_{cb,\underline{t}}x_t$. Agents observe i_t, infer $F_{cb,\underline{t}}x_t$, and form $F_{i,\bar{t}}x_t$. Trade is a function of the aggregate expectation revision between $\underline{t}$ and $\bar{t}$.

A A model of information effects with high and low noise

Let us consider a model in which private agents and the central bank have imperfect information about the state of the economy, and form expectations conditional on private signals clouded by state dependent observational noise. In doing so we extend the model in Miranda-Agrippino and Ricco (2021) to the case where the variance of the noise is not constant.

Agents in the model live in a discrete time, with each period t being dividend in an opening and a closing stage, i.e. $t \in \{\underline{t}, \bar{t}\}$. The inflation process evolves over time with an AR(1) process:

$$\pi_t = \rho\pi_{t-1} + u_t^\pi \qquad u_t^\pi \sim \mathcal{N}(0, \sigma_\pi^2) \ , \tag{1}$$

with normally distributed innovations, u_t^π, and $|\rho| < 1$.

At beginning of time t, i.e. $\underline{t}$, the private agents receive a private signal about inflation contaminated by observational noise

$$s_{i,t} = \pi_t + v_{i,t} \qquad v_{i,t} \sim \mathcal{N}(0, \sigma^2_{v,z}), \tag{2}$$

with a state-dependent variance, σ^v_s, which is equal across agents and is characterised by the existence of two states, $z \in \{L, H\}$, respectively with high and low noise, i.e. $\sigma^v_{H,z} > \sigma^v_{L,z}$. Agents form and update their expectations about current and future inflation, conditional on the signals observed using a Kalman filter

$$F_{i,\underline{t}}\pi_t = K_{1,\underline{t}} s_{i,\underline{t}} + (1 - K_{1,\underline{t}}) F_{i,\overline{t-1}}\pi_t, \tag{3}$$

$$F_{i,\underline{t}}\pi_{t+h} = \rho F_{i,\underline{t}}\pi_t, \tag{4}$$

where $K^z_{1,t}$ is the Kalman gain. Conditional on their forecasts, agents form expectation and trade the policy rate that will be set by the central bank following a Taylor rule

$$i^{(0)}_t = r_t = \delta\pi_t + u^{mp}_t, \tag{5}$$

and interest rates at longer horizons, i.e $i^{(h)}_t$ for $h \geq 0$

$$i^{(h)}_{\underline{t}} = \alpha_h F_{\underline{t}}\pi_{t+h} + \xi^{(h)}_t = \widetilde{\alpha}_h F_{\underline{t}} r_{t+h} + \xi^{(h)}_t, \tag{6}$$

where $\xi^{(h)}_t$ captures risk premia, $\alpha_0 = \delta$, and $F_{\underline{t}}$ indicate the average expectations over the market.

Let us define $V_{t|\overline{t-1}} \equiv \mathrm{Var}\left(\pi_t - F_{i,\overline{t-1}}\pi_t\right)$, i.e. the variance of the forecast errors for inflation at time t, made at time $\overline{t-1}$. The Kalman gain $K_{1,\underline{t}}$ is given by:

$$K_{1,\underline{t}} = \frac{V_{t|\overline{t-1}}}{V_{t|\overline{t-1}} + \sigma^2_{v,z}}. \tag{7}$$

From the expression for $K_{1,\underline{t}}$, it is clear that, for a given $V_{t,\overline{t-1}}$, the agents will update more their forecasts in states of low noise, as compared to the states of high noise.

The variance of the forecast of π_t made at $\underline{t}$ will depend on $V_{t|\overline{t-1}}$ as[1]

$$V_{t|\underline{t}} = V_{t|\overline{t-1}} - \frac{(V_{t|\overline{t-1}})^2}{V_{t|\overline{t-1}} + \sigma^2_{v,z}}, \tag{8}$$

$$V_{t|\overline{t-1}} = \rho^2 V_{t-1|\overline{t-1}} + \sigma^2_{\pi} \tag{9}$$

During period t, the central bank receives a private signal about the state of the economy, contaminated by a noise of constant volatility, and updates its forecast:

$$s_{cb,t} = \pi_t + v_{cb,t} \qquad v_{cb,t} \sim \mathcal{N}(0, \sigma^2_{v,cb}), \tag{10}$$

$$F_{cb,t}\pi_t = K_{cb,t}s_{cb,t} + (1 - K_{cb,t})F_{cb,t-1}\pi_t. \tag{11}$$

The assumption of constant volatility captures in a stylised manner the fact that the central bank, differently from market operators which have to sample information from prices and data releases, can have a more direct access to data offices and even survey directly financial and economic institutions to take the pulse to the economy. Given the constant noise in the central bank's signal, we can consider the asymptotic value of the Kalman gain, K_{cb}, where we drop the index t.

Conditional on its forecast for π_t, the central bank set and announces the interest rate for the period:

$$r_t = \delta F_{cb,t}\pi_t + u_t^{mp}. \tag{12}$$

where u_t^{mp} is a monetary policy shocks drawn from a normal distribution centred at zero and with variance σ^2_{mp}.

[1]Agents in the model know all of the model parameters, including the variance of the signal (either low or high).

At time $\bar{t}$, agents observe the interest rate

$$r_t = \delta \left(K_{cb} s_{cb,t} + (1 - K_{cb}) F_{cb,t-1} \pi_t\right) + u_t^{mp} \tag{13}$$

$$= \delta K_{cb} \pi_t + \delta K_{cb} v_{cb,t} + (1 - K_{cb}) \rho F_{cb,t-1} \pi_{t-1} + u_t^{mp} \tag{14}$$

$$= \delta K_{cb} \pi_t + \delta K_{cb} v_{cb,t} + (1 - K_{cb}) \rho \left(i_{t-1} - u_{t-1}^{mp}\right) + u_t^{mp} \ , \tag{15}$$

i.e. conditional on the past interest rate, a public signal on the state of the economy:

$$\tilde{s}_{\bar{t}} = \pi_t + \tilde{v}_{cb,\underline{t}} \equiv \pi_t + v_{cb,t} + (\delta K_{cb})^{-1} [u_t^{mp} - (1 - K_{cb}) \rho u_{t-1}^{mp}]. \tag{16}$$

Given this public signal, agents update their expectations[2]

$$F_{i,\bar{t}} \pi_t = K_{2,\bar{t}} \tilde{s}_{cb,\bar{t}} + (1 - K_{2,\bar{t}}) F_{i,\underline{t}} \pi_t,$$

where the gain $K_{2,\bar{t}}$ is:

$$K_{2,\bar{t}} = \frac{V_{t|\underline{t}}}{V_{t|\underline{t}} + \sigma_{\tilde{v}}^2}, \tag{17}$$

and the forecast error variance is such that:

$$V_{t|\bar{t}} = V_{t|\underline{t}} - \frac{(V_{t|\underline{t}})^2}{V_{t|\underline{t}} + \sigma_{\tilde{v}}^2}. \tag{18}$$

Conditional on their updated forecasts, agents revise the price for the rates at longer horizons and trade.

Proposition 1. *The price revisions in interest rates at different maturities triggered by the*

[2]For sake of simplicity we assume that agents update with a standard Kalman filter without taking into account the structure in the noise of this public signal due to the moving average component in the monetary policy shock.

policy announcement are

$$\Delta i_{\underline{t}}^{(h)} = \alpha_h \rho^h \left(F_{\bar{t}} \pi_t - F_{\underline{t}} \pi_t \right) + \Delta \xi_t^{(h)}, \tag{19}$$

where

$$\begin{aligned} F_{\bar{t}}\pi_t - F_{\underline{t}}\pi_t = {} & (1 - K_{1,\underline{t}}) K_{2,\bar{t}} K_{2,\overline{t-1}}^{-1} (1 - K_{2,\overline{t-1}}) [F_{\overline{t-1}}\pi_t - F_{\underline{t-1}}\pi_t] + (K_{2,\bar{t}})(1 - K_{1,\underline{t}}) u_t^{\pi} \\ & + K_{2,\bar{t}} [\nu_{cb,\underline{t}} - (1 - K_{1,\underline{t}}) \rho \nu_{cb,\underline{t-1}}] + K_{2,\bar{t}} (K_{cb}\delta)^{-1} [u_t^{mp} - \rho(2 - K_{cb} - K_{1,\underline{t}}) u_{t-1}^{mp} \\ & + (1 - K_{1,\underline{t}})(1 - K_{cb}) \rho^2 u_{t-2}], \end{aligned} \tag{20}$$

are the average revision in expectations across agents in the market, and $\Delta\xi_t^{(h)}$ *are revisions to risk premia.*

Proof. Eq. (20) follows readily from the same derivations reported in the Online Appendix of Miranda-Agrippino and Ricco (2021), but for $K_{1,\underline{t}}$ and $K_{2,\overline{t-1}}$ time-varying. Eq. (19) is obtained from Eq. (5) and Eq. (6). □

The expression in Eq. (20) shows that after observing the policy decision agent all update their expectations towards the view of the bank, hence inducing a market wide information effect. The term $(K_{2,\bar{t}})(1 - K_{1,\underline{t}})u_t^{\pi}$ captures the information channel of the monetary policy, while the first term in the expression above the autocorrelation between revision of expectations that is due to the sluggish adjustment of expectations in models of imperfect information.

We are here interested in understanding how states of low and high variance change the strength of information effects. Let us first prove that the asymptotic variance of the forecast errors, where one assumes that only one state is realised, is increasing with the variance of the noise, while the Kalman gain is decreasing.

Using the formulae of the Kalman recursion and first substituting Eq. (9), and then Eq.

(18), into Eq. (8)

$$
\begin{aligned}
V_{t|\underline{t}} &= V_{t|\overline{t-1}} - \frac{(V_{t|\overline{t-1}})^2}{V_{t|\overline{t-1}} + \sigma_{v,z}^2} \;= \rho^2 V_{t-1|\overline{t-1}} + \sigma_\pi^2 - \frac{(\rho^2 V_{t-1|\overline{t-1}} + \sigma_\pi^2)^2}{\rho^2 V_{t-1|\overline{t-1}} + \sigma_\pi^2 + \sigma_{v,z}^2} \\
&= \frac{(\rho^2 V_{t-1|\overline{t-1}} + \sigma_\pi^2)\sigma_{v,z}^2}{\rho^2 V_{t-1|\overline{t-1}} + \sigma_\pi^2 + \sigma_{v,z}^2} = \frac{(\rho^2 \frac{V_{t-1|\underline{t-1}}\sigma_{\tilde{v}}^2}{V_{t-1|\underline{t-1}} + \sigma_{\tilde{v}}^2} + \sigma_\pi^2)\sigma_{v,z}^2}{\rho^2 \frac{V_{t-1|\underline{t-1}}\sigma_{\tilde{v}}^2}{V_{t-1|\underline{t-1}} + \sigma_{\tilde{v}}^2} + \sigma_\pi^2 + \sigma_{v,z}^2} \\
&= \frac{(\rho^2 (V_{t-1|\underline{t-1}}\sigma_{\tilde{v}}^2) + \sigma_\pi^2 (V_{t-1|\underline{t-1}} + \sigma_{\tilde{v}}^2))\sigma_{v,z}^2}{\rho^2 (V_{t-1|\underline{t-1}}\sigma_{\tilde{v}}^2) + (\sigma_\pi^2 + \sigma_{v,z}^2)(V_{t-1|\underline{t-1}} + \sigma_{\tilde{v}}^2)},
\end{aligned}
\tag{21}
$$

and hence the asymptotic variance, V, of the forecast error, $V_{t|\underline{t}}$, solves the quadratic equation

$$
V = \frac{(\rho^2 V \sigma_{\tilde{v}}^2 + \sigma_\pi^2 (V + \sigma_{\tilde{v}}^2))\sigma_{v,z}^2}{\rho^2 V \sigma_{\tilde{v}}^2 + (\sigma_\pi^2 + \sigma_{v,z}^2)(V + \sigma_{\tilde{v}}^2)}
\tag{22}
$$

which admits only one positive solution:

$$
\begin{aligned}
V =& \frac{-\sigma_\pi^2 \sigma_{\tilde{v}}^2 + \sigma_\pi^2 \sigma_{v,z}^2 - (1-\rho^2)\sigma_{\tilde{v}}^2 \sigma_{v,z}^2}{2\left(\sigma_\pi^2 + \sigma_{\tilde{v}}^2 \rho^2 + \sigma_{v,z}^2\right)} \\
&+ \frac{\sqrt{\left(\sigma_\pi^2 \sigma_{\tilde{v}}^2 - \sigma_\pi^2 \sigma_{v,z}^2 + (1-\rho^2)\sigma_{\tilde{v}}^2 \sigma_{v,z}^2\right)^2 + 4\sigma_\pi^2 \sigma_{\tilde{v}}^2 \sigma_{v,z}^2 \left(\sigma_\pi^2 + \sigma_{\tilde{v}}^2 \rho^2 + \sigma_{v,z}^2\right)}}{2\left(\sigma_\pi^2 + \sigma_{\tilde{v}}^2 \rho^2 + \sigma_{v,z}^2\right)}.
\end{aligned}
\tag{23}
$$

To understand how V depends on the variance of the noise we can look at the equations defining the asymptotic values of the forecast error variances at different points in time

$$
V = \frac{W \sigma_{v,z}^2}{W + \sigma_{v,z}^2},
\tag{24}
$$

$$
W = \rho^2 U + \sigma_\pi^2,
\tag{25}
$$

$$
U = \frac{V \sigma_{\tilde{v}}^2}{V + \sigma_{\tilde{v}}^2},
\tag{26}
$$

where V, W and U are the asymptotic values of $V_{t|\underline{t}}$, $V_{t|\overline{t-1}}$ and $V_{t-1|\overline{t-1}}$, respectively. In particular we consider the case where only one value of the observational noise variance is realised and how the asymptotic values of the forecast error variances depends on it. We now prove the following proposition.

Proposition 2. *The asymptotic variances of the forecast errors of the Kalman filter are increasing in the noise in the private signals received by the agents, i.e.*

$$\frac{dV}{d\sigma^2_{v,z}} > 0, \qquad \frac{dW}{d\sigma^2_{v,z}} > 0, \qquad \frac{dU}{d\sigma^2_{v,z}} > 0, \tag{27}$$

and hence

$$V^H > V^L, \qquad W^H > W^L, \qquad U^H > U^L. \tag{28}$$

Proof. Taking derivative in $\sigma^2_{v,z}$ one finds

$$\begin{aligned}
\frac{dV}{d\sigma^2_{v,z}} &= \frac{1}{(W+\sigma^2_{v,z})^2}\left(\left(\frac{dW}{d\sigma^2_{v,z}}\sigma^2_{v,z} + W\right)(W+\sigma^2_{v,z}) - W\sigma^2_{v,z}\left(\frac{dW}{d\sigma^2_{v,z}}+1\right)\right) \\
&= \frac{1}{(W+\sigma^2_{v,z})^2}\left(W^2 + \sigma^4_{v,z}\frac{dW}{d\sigma^2_{v,z}}\right), \qquad (29)\\
\frac{dW}{d\sigma^2_{v,z}} &= \rho^2 \frac{dU}{d\sigma^2_{v,z}}, \qquad (30)\\
\frac{dU}{d\sigma^2_{v,z}} &= \frac{1}{(V+\sigma^2_{\tilde{v}})^2}\left(\frac{dV}{d\sigma^2_{v,z}}\sigma^2_{\tilde{v}}(V+\sigma^2_{\tilde{v}}) - V\sigma^2_{\tilde{v}}\frac{dV}{d\sigma^2_{v,z}}\right) = \frac{\sigma^4_{\tilde{v}}}{(V+\sigma^2_{\tilde{v}})^2}\frac{dV}{d\sigma^2_{v,z}}. \qquad (31)
\end{aligned}$$

Substituting Eq. (31) and Eq. (30) in Eq. (29), one gets

$$\frac{dV}{d\sigma^2_{v,z}} = \left(1 - \frac{\rho^2\sigma^4_{v,z}}{(W+\sigma^2_{v,z})^2}\frac{\sigma^4_{\tilde{v}}}{(V+\sigma^2_{\tilde{v}})^2}\right)^{-1}\frac{W^2}{(W+\sigma^2_{v,z})^2}. \tag{32}$$

The proposition is obtained by observing that the term in parentheses is greater than zero, and that the signs $dV/d\sigma^2_{v,z}$ determines the sign of $dW/d\sigma^2_{v,z}$ and $dU/d\sigma^2_{v,z}$ due to Eq. (30) and (31). □

This result indicates that when the economy moves from a regime with low noise to a regime of high noise, all the errors at different steps increase, and vice versa. This result will be important in proving how information effects depend on the variance of the noise in the private signals of the agents. Before doing so, we can also prove the following propositions.

Proposition 3. *The steady state variances of the forecast errors of the Kalman filter are all increasing in the noise in the public signal delivered by the central bank via the interest rate decisions, which depends on the variance of monetary policy shocks and of the noise in the private signal received by the central bank, i.e.*

$$\frac{dV}{d\sigma^2_{\tilde{v}}} > 0, \qquad \frac{dW}{d\sigma^2_{\tilde{v}}} > 0, \qquad \frac{dU}{d\sigma^2_{\tilde{v}}} > 0. \tag{33}$$

Proof. Following the same steps used in proving Proposition 2, one finds that

$$\frac{dU}{d\sigma^2_{\tilde{v}}} = \left(1 - \frac{\rho^2\sigma^4_{v,z}}{(W+\sigma^2_{v,z})^2}\frac{\sigma^4_{\tilde{v}}}{(V+\sigma^2_{\tilde{v}})^2}\right)^{-1}\frac{V^2}{(V+\sigma^2_{\tilde{v}})^2}, \tag{34}$$

from which follows the statement of the proposition. □

Proposition 4. *The steady state variances of the forecast errors of the Kalman filter are all increasing in the variance of the shock to the inflation process.*

Proof. We can observe that

$$\frac{dW}{d\sigma^2_{\pi}} = \left(1 - \frac{\rho^2\sigma^4_{v,z}}{(W+\sigma^2_{v,z})^2}\frac{\sigma^4_{\tilde{v}}}{(V+\sigma^2_{\tilde{v}})^2}\right)^{-1}. \tag{35}$$

which delivers the result. □

We can now prove the following result.

Proposition 5. *The information channel of monetary policy strengthens with the increase in the noise in the economy, i.e.*

$$\frac{d}{d\sigma^2_{v,z}}(K_{2,\bar{t}}(1-K_{1,\underline{t}})) > 0, \tag{36}$$

and hence

$$K_2^H(1-K_1^H) > K_2^L(1-K_1^L), \tag{37}$$

where K_1^H), K_1^L and K_2^H), K_2^L are the asymptotic values of the Kalman gains in the states of high and low variance, respectively.

Proof. Let us first prove that the Kalman gain $K_{1,\underline{t}}$ is decreasing with the variance of the noise. Let us consider the derivative of $K_{1,\underline{t}}$ in $\sigma^2_{v,z}$

$$\frac{dK_{1,\underline{t}}}{d\sigma^2_{v,z}} = \frac{1}{(V_{t|\overline{t-1}} + \sigma^2_{v,z})^2}\left(\sigma^2_{v,z}\frac{dV_{t|\overline{t-1}}}{d\sigma^2_{v,z}} - V_{t|\overline{t-1}}\right), \tag{38}$$

which shows that asymtotically the sign of $dK_{1,\underline{t}}/d\sigma^2_{v,z}$ depends on the sign of

$$\frac{\sigma^2_{v,z}}{W}\frac{dW}{d\sigma^2_{v,z}} - 1 \tag{39}$$

Let us first express the term of interest as

$$\begin{aligned}
\frac{\sigma^2_{v,z}}{W}\frac{dW}{d\sigma^2_{v,z}} &= \frac{\sigma^2_{v,z}}{\rho^2\frac{V\sigma^2_{\tilde{v}}}{V+\sigma^2_{\tilde{v}}} + \sigma^2_{\pi}}\frac{dW}{d\sigma^2_{v,z}} &(40)\\
&= \frac{\sigma^2_{v,z}}{\rho^2\frac{V\sigma^2_{\tilde{v}}}{V+\sigma^2_{\tilde{v}}} + \sigma^2_{\pi}}\rho^2\frac{dU}{d\sigma^2_{v,z}} &(41)\\
&= \frac{\sigma^2_{v,z}}{\rho^2\frac{V\sigma^2_{\tilde{v}}}{V+\sigma^2_{\tilde{v}}} + \sigma^2_{\pi}}\rho^2\frac{\sigma^4_{\tilde{v}}}{(V+\sigma^2_{\tilde{v}})^2}\frac{dV}{d\sigma^2_{v,z}} &(42)
\end{aligned}$$

where we first used Eq.s (25-26), and then Eq.s (30-31). We can now observe that for the first factor in the above expression it is true that

$$\begin{aligned}
\frac{\rho^2\sigma^2_{v,z}\sigma^4_{\tilde{v}}}{\left(\rho^2\frac{V\sigma^2_{\tilde{v}}}{V+\sigma^2_{\tilde{v}}} + \sigma^2_{\pi}\right)(V+\sigma^2_{\tilde{v}})^2} &= \frac{\rho^2\sigma^2_{v,z}\sigma^4_{\tilde{v}}}{(\rho^2V\sigma^2_{\tilde{v}} + \sigma^2_{\pi}(V+\sigma^2_{\tilde{v}}))\,(V+\sigma^2_{\tilde{v}})} &(43)\\
&< \frac{\rho^2\sigma^2_{v,z}\sigma^4_{\tilde{v}}}{\rho^2V\sigma^2_{\tilde{v}}(V+\sigma^2_{\tilde{v}})} = \frac{\sigma^2_{v,z}\sigma^2_{\tilde{v}}}{V(V+\sigma^2_{\tilde{v}})} < \frac{\sigma^2_{v,z}}{V}. &(44)
\end{aligned}$$

Hence it holds that $\frac{\sigma^2_{v,z}}{V}\frac{dV}{d\sigma^2_{v,z}} < 1$ then it is also true that $\frac{\sigma^2_{v,z}}{W}\frac{dW}{d\sigma^2_{v,z}} < 1$. Let us now focus on this simplified problem:

$$
\begin{aligned}
\frac{\sigma_{v,z}^2}{V}\frac{dV}{d\sigma_{v,z}^2} &= \frac{\sigma_{v,z}^2}{V}\left(1-\frac{\rho^2\sigma_{v,z}^4}{(W+\sigma_{v,z}^2)^2}\frac{\sigma_{\tilde{v}}^4}{(V+\sigma_{\tilde{v}}^2)^2}\right)^{-1}\frac{W^2}{(W+\sigma_{v,z}^2)^2}\\
&= \frac{\sigma_{v,z}^2}{V}\left(1-\frac{\rho^2\sigma_{v,z}^4}{(W+\sigma_{v,z}^2)^2}\frac{\sigma_{\tilde{v}}^4}{(V+\sigma_{\tilde{v}}^2)^2}\right)^{-1}\frac{W^2}{(W+\sigma_{v,z}^2)^2}\\
&= \frac{\sigma_{v,z}^2}{\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}}\left(1-\frac{\rho^2\sigma_{v,z}^4}{(W+\sigma_{v,z}^2)^2}\frac{\sigma_{\tilde{v}}^4}{\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2}\right)^{-1}\frac{W^2}{(W+\sigma_{v,z}^2)^2}\\
&= \frac{W}{(W+\sigma_{v,z}^2)}\left(1-\frac{\rho^2\sigma_{v,z}^4}{(W+\sigma_{v,z}^2)^2}\frac{\sigma_{\tilde{v}}^4}{\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2}\right)^{-1}\\
&= \frac{W}{(W+\sigma_{v,z}^2)}\left(\frac{(W+\sigma_{v,z}^2)^2\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2-\rho^2\sigma_{v,z}^4\sigma_{\tilde{v}}^4}{(W+\sigma_{v,z}^2)^2\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2}\right)^{-1}\\
&= W\left(\frac{(W+\sigma_{v,z}^2)\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2}{(W+\sigma_{v,z}^2)^2\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2-\rho^2\sigma_{v,z}^4\sigma_{\tilde{v}}^4}\right)\\
&= \frac{(W^2+W\sigma_{v,z}^2)\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2}{(W^2+W\sigma_{v,z}^2+W\sigma_{v,z}^2+\sigma_{v,z}^4)\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2-\rho^2\sigma_{v,z}^4\sigma_{\tilde{v}}^4}.
\end{aligned}
$$

Let us define $\Delta \equiv (W+\sigma_{v,z}^2)\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2$. Hence we can write

$$
\begin{aligned}
\frac{\sigma_{v,z}^2}{V}\frac{dV}{d\sigma_{v,z}^2} &= \frac{\Delta}{\Delta+(W\sigma_{v,z}^2+\sigma_{v,z}^4)\left(\frac{W\sigma_{v,z}^2}{W+\sigma_{v,z}^2}+\sigma_{\tilde{v}}^2\right)^2-\rho^2\sigma_{v,z}^4\sigma_{\tilde{v}}^4}\\
&= \frac{\Delta(W+\sigma_{v,z}^2)^2}{\Delta(W+\sigma_{v,z}^2)^2+(W\sigma_{v,z}^2+\sigma_{v,z}^4)\left(W\sigma_{v,z}^2+\left(W+\sigma_{v,z}^2\right)\sigma_{\tilde{v}}^2\right)^2-\rho^2\sigma_{v,z}^4\sigma_{\tilde{v}}^4(W+\sigma_{v,z}^2)^2}.
\end{aligned}
$$

We can now define $\Delta' \equiv \Delta(W+\sigma_{v,z}^2)^2$ to rewrite

$$
\frac{\sigma_{v,z}^2}{V}\frac{dV}{d\sigma_{v,z}^2} = \frac{\Delta'}{\Delta'+\chi_1+\chi_2},
$$

where χ_1 and χ_2 are defined as

$$\chi_1 \equiv (1-\rho^2)\sigma^4_{v,z}\sigma^4_{\tilde{v}}(W+\sigma^2_{v,z})^2,$$
$$\chi_2 \equiv (W\sigma^2_{v,z})\left(W^2\sigma^4_{v,z} + \left(W+\sigma^2_{v,z}\right)^2\sigma^4_{\tilde{v}} + 2W\sigma^2_{v,z}\left(W+\sigma^2_{v,z}\right)\sigma^2_{\tilde{v}}\right)$$
$$+\sigma^4_{v,z}\left(W^2\sigma^4_{v,z} + 2W\sigma^2_{v,z}\left(W+\sigma^2_{v,z}\right)\sigma^2_{\tilde{v}}\right).$$

Observing that Δ' is positive, χ_1 is positive since $|\rho| < 1$, and χ_2 is the sum of positive terms, it follows that

$$\frac{\sigma^2_{v,z}}{V}\frac{dV}{d\sigma^2_{v,z}} < 1, \tag{45}$$

and hence that the Kalman gain $dK_{1,\underline{t}}$ is decreasing in the private noise, i.e.

$$\frac{dK_{1,\underline{t}}}{d\sigma^2_{v,z}} < 0. \tag{46}$$

We can now observe that

$$\frac{K_{2,\bar{t}}}{d\sigma^2_{v,z}} = \frac{1}{(V_{t|\underline{t}} + \sigma^2_{\tilde{v}})^2}\sigma^2_{\tilde{v}}\frac{dV_{t|\underline{t}}}{d\sigma^2_{v,z}} > 0, \tag{47}$$

which follows from Eq. (27).

The proposition is then proved observing that $K_{2,\bar{t}}$ is increasing in the variance of the noise of the private signals obtained by the agents, while $K_{1,\underline{t}}$ is decreasing in it. □

B Data

In our empirical analysis we employ the following series.

- HICP - All-items excluding energy and food from Eurostat
  (Core HICP – 'ICP.M.U2.N.XEF000.4.INX' on the ECB website)

- HICP - All-items from Eurostat ('ICP.M.U2.N.000000.4.INX' on the ECB website)

- Industrial Production for the Euro Area including construction from Eurostat (2015 = 100). The series includes mining and quarrying, manufacturing, electricity, gas, steam and air conditioning supply, and construction sectors. It is seasonally adjusted. The series can be found at https://doi.org/10.2908/STS_COPR_M.

- Industrial production Italy and Germany from Eurostat (Seasonally Adjusted series – reference: 'STS_INPR_M').

- Real GDP and GDP deflator are obtained by interpolation using a Kalman filter following the methodology of Stock and Watson (2010) and Jarociński and Karadi (2020). The list of variables show the quarterly variables used in the exercise, all sourced from Eurostat. Each sub-list contains the monthly indicators used for the interpolation of the quarterly variable, along with its source.

  - Private final consumption
    * Retail trade - 'TRD.M.I8.Y.M.CON.J8.4.VAL' from Statistical Data Warehouse (SDW)
    * Imports of consumer goods - 'STS.M.I8.Y.TOVV.NS4701.4.000' from SDW
  - Government final consumption
  - Gross fixed capital formation
    * Construction output - 'STS_COPR_M' from Eurostat

- Change in business inventories and acquisitions less disposable values
  - Stocks of finished products - 'INDU.EA.TOT.4.BS.M' from Eurostat
  - Volume of stocks - 'RETA.EA.TOT.2.BS.M' from Eurostat
- Net exports of goods and services
  - Trade balance in goods with rest of world - 'XTEXVA01EZM664S, XTIMVA01EZM664S' from Federal Reserve Economic Data (FRED)
  - Volume of export order books - 'INDU.EA.TOT.3.BS.M' from Eurostat
  - Manufacturing new orders - 'STS.M.I8.Y.ORDX.NSC002.3.000' from SDW
- GDP deflator
  - HICP - 'ICP.M.U2.Y.000000.3.INX' from SDW
  - Domestic PPI - 'STS_INPPD_M' from Eurostat

- OIS rates are obtained from Datastream and Bloomberg. For 1m-OIS and 3m-OIS and 10y-OIS, we use the last price of the Datastream daily series. For 1y-OIS and 2y-OIS we employ the last price of the daily series from Bloomberg.

- Exchange rate euros to dollar from Eurostat as monthly average (https://doi.org/10.2908/ERT_BIL_EUR_M).

- 10 year German government bond yield (GTDEM10Y) and the 10 year Italian government bond yield (GTITL10Y) from Bloomberg.

- The spread between the 10 year German government bond yield and the 10 year Italian government bond yield are computed as monthly averages of the spread from Datastream.

- NEW We also use the peak and trough quarters for the euro area identified by the CEPR-EABCN Euro Area Business Cycle Dating Committee.[3]

[3] See the following website for the specific dates: https://eabcn.org/dbc/peaksandtroughs/chronology-euro-area-business-cycles.

NEW In our information specifications, we use two sources.

- ECB forecasts from the Macroeconomic Projection Database that are released quarterly (March, June, September, and December). Specifically, we use quarterly and annual growth rate forecasts for HICP and real GDP.[4] The key series for quarterly HICP is '440.MPD.Q.U2.HIC.A.XXX.XXXX', with the last part varying by forecast season and horizon. For annual HICP, the key series is '440.MPD.A.U2.HIC.A.XXX.XXXX'. The key series for quarterly and annual real GDP forecasts are '440.MPD.A.U2.YER.P.XXX.XXXX' and '440.MPD.Q.U2.YER.P.XXX.XXXX'.

- Reuters forecasts from Economic Indicator Polls (Long-term Outlook, Poll History) for GDP and HICP, providing quarterly and annual percentage changes in GDP forecasts, and quarterly and annual percentage changes (year-over-year) for HICP. We also use Central Bank Polls (Long-term Outlook, Poll History) for quarterly ECB Refinancing Rate forecasts. All the data are collected from the Eikon terminal.

B.1 On core inflation

In our analysis we do not employ the seasonally adjusted series for core inflation from the ECB. A note in the ECB website explains how in 2015 the German price index for package holidays has changed the seasonal adjustment pattern.[5]

Eurostat has adjusted the series whereas the ECB series still display some distortion especially in 2015 (see Chart C in the ECB article).[6]

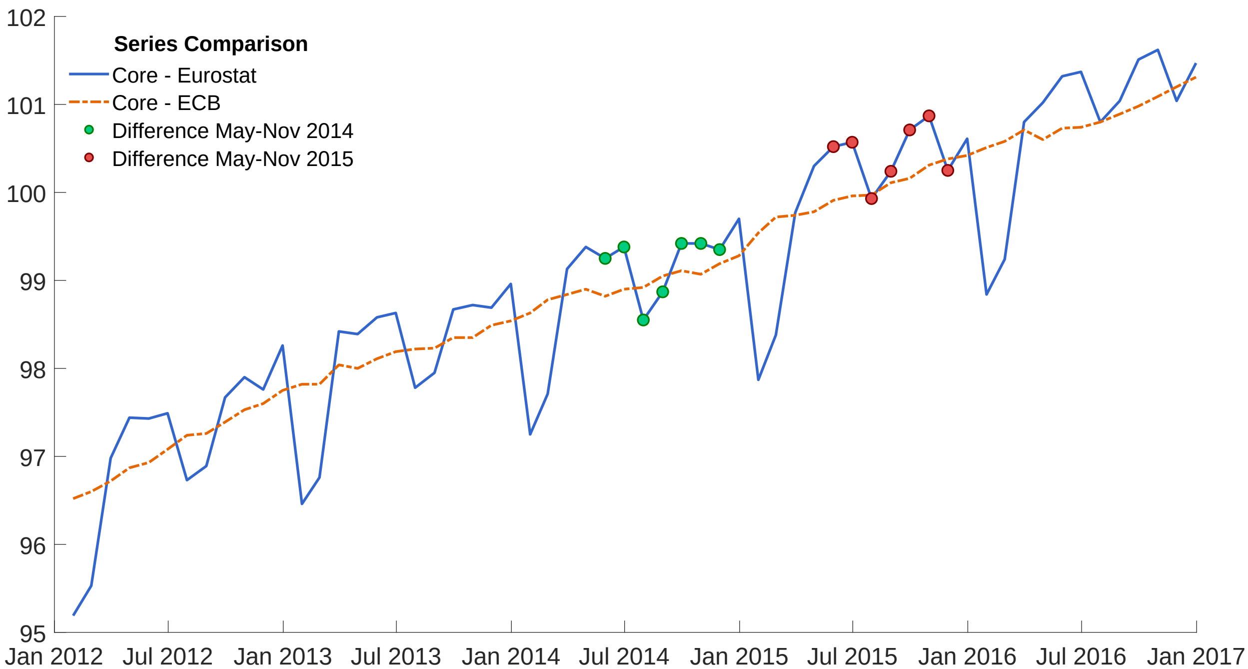
In Figure B.2, we report how from September 2015 up to December 2015 the seasonal pattern of the HICP core (Eurostat) displays a larger peak than usual. We decided to use the Core measure from Eurostat for the adjustment reported in the Eurostat series. The

[4]Available on the ECB's website: `https://data.ecb.europa.eu/data/datasets/MPD`.

[5]See 'A new method for the package holiday price index in Germany and its impact on HICP inflation rates' published as part of the ECB Economic Bulletin, Issue 2/2019.

[6]See Eurostat, 'Improved calculation of HICP special aggregates and German package holidays methodological change', February 2019, p. 2 for the description of the changes

Figure B.2: Core in the Euro Area - ECB and Eurostat measures



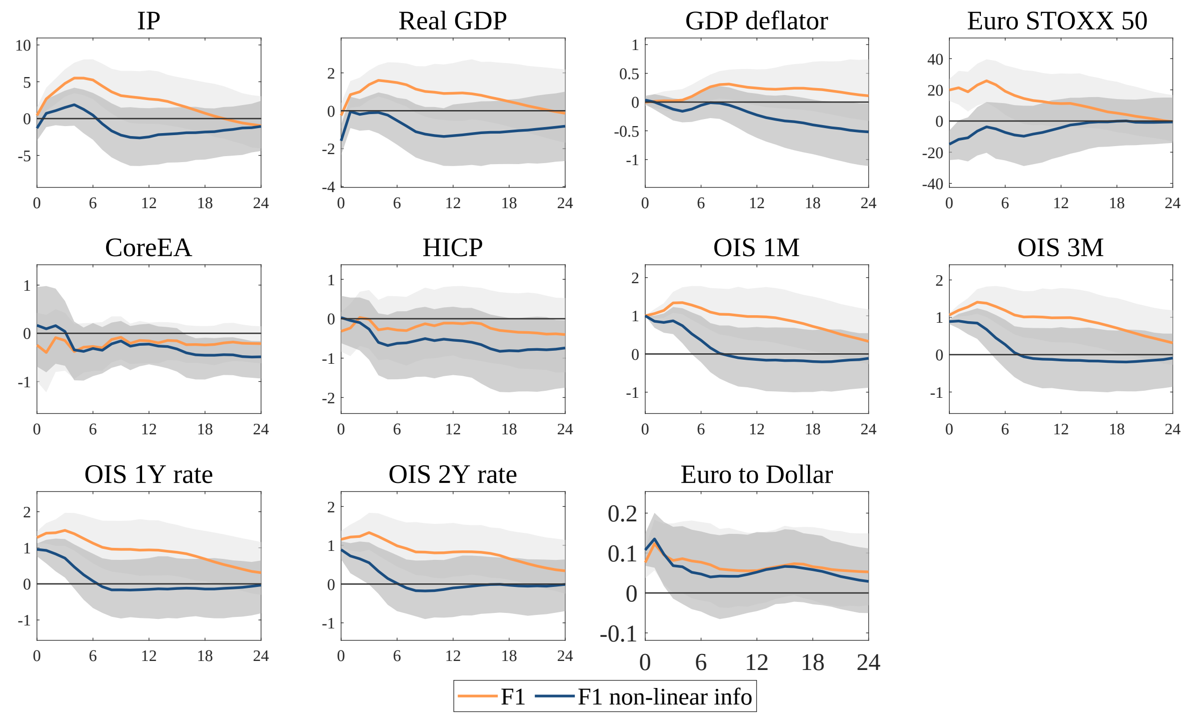
Notes: The figure reports the difference in May-Nov 2015 of the ECB series (in orange) and Eurostat series (in blue). The blue circle shows how the peak in September 2015 for the Eurostat series was larger than the previous peaks during the same period of the year. This is consistent with the Chart C of the ECB note.

results of the paper with the Core measures of the ECB are similar but we decided to use the Eurostat series because we are sure of the adjustment as reported in the Eurostat note.

B.2 On industrial production

The series for industrial production we employ, which include constructions, is slightly different from the industrial production series excluding construction. The results in the paper are not affected by the choice of the series. For example, in Figure B.3 we report the IRFs of a 100 basis point tightening identified with the Target factor. We use the measure of industrial production excluding construction from the ECB ('STS.M.I9.Y.PROD.NS0020.4.000').

Figure B.3: IRFs to 100 basis points tightening in 1m-OIS - IP excluding construction



C Factor extraction

We employ the high-frequency price changes on 14 variables as reported in the Euro Area Monetary Policy Database (EA-MPD): 1-month OIS, 3-month OIS, 6-month OIS, 1-year OIS, 2-year OIS, 5-year OIS, 10-year OIS, 2-year SPREAD, 5-year SPREAD, 10-year SPREAD, EURGBP, EURJPY EURUSD, and STOXX50. We sum of the price changes in release and conference window. Differently to what done by Altavilla et al. (2019), we do not remove any observation in this time period.

The factor structure is:

$$Y = F\Lambda + \epsilon, \tag{48}$$

where Y is a $T \times 14$ matrix of surprises with T representing the number of ECB governing council meetings from 2002 to 2019. We extract four factors from these surprises. F represents the matrix of factors which, in our case, is $T \times 4$ and Λ is the loading matrix (4×14).

The factor structure is not unique. Consider an orthonormal matrix U (4×4) such that $UU' = I$:

$$Y = \tilde{F}\tilde{\Lambda} + \epsilon, \tag{49}$$

where $\tilde{F} = FU$ and $\tilde{\Lambda} = U'\Lambda$, which defines new matrices $\tilde{F}$ and $\tilde{\Lambda}$ consistent with the factor structure. Given the existence of 4 factors, 16 restrictions are needed to identify U, up to a sign.

Suppose $X_{.,j}$ is the $j-th$ column of matrix X and $X_{i,.}$ is the $i-th$ row of matrix X. The orthogonality of the columns provides 6 restrictions:

$$U'_{.,1}U_{.,2} = 0, U'_{.,1}U_{.,3} = 0, U'_{.,1}U_{.,4} = 0,$$
$$U'_{.,2}U_{.,3} = 0, U'_{.,2}U_{.,4} = 0, U'_{.,3}U_{.,4} = 0$$

The normalisation of the columns delivers 4 additional restrictions:

$$U'_{.,1}U_{.,1} = 1, U'_{.,2}U_{.,2} = 1, U'_{.,3}U_{.,3} = 1, U'_{.,4}U_{.,4} = 1$$

Thus, one has to define 6 additional restrictions to uniquely identify U (up to sign).

Following Gürkaynak et al. (2005) and Altavilla et al. (2019), we impose that all the factors apart from the target factor have zero effect on the 1-month OIS. This provides three additional restrictions:

$$U'_{.,2}\Lambda_{.,1} = 0, U'_{.,3}\Lambda_{.,1} = 0, U'_{.,4}\Lambda_{.,1} = 0$$

Following Swanson (2021) and Altavilla et al. (2019), we impose that the QE/QT factor has minimal variance in the pre-crisis period (January 2002-7 August 2008).[7]

We finally impose two restrictions on the fourth factor. First, we impose that it has zero

[7]Note that the uniqueness is up to a sign, so we have four scale normalisation. Altavilla et al. (2019) imposes that the three factors Target, Forward Guidance and Quantitative Easing are positively correlated with OIS 1 month, OIS 2 years and OIS 10 years, respectively. We do the same and we impose that the fourth factor, country risk factor, is positively correlated with 10-year Spread.

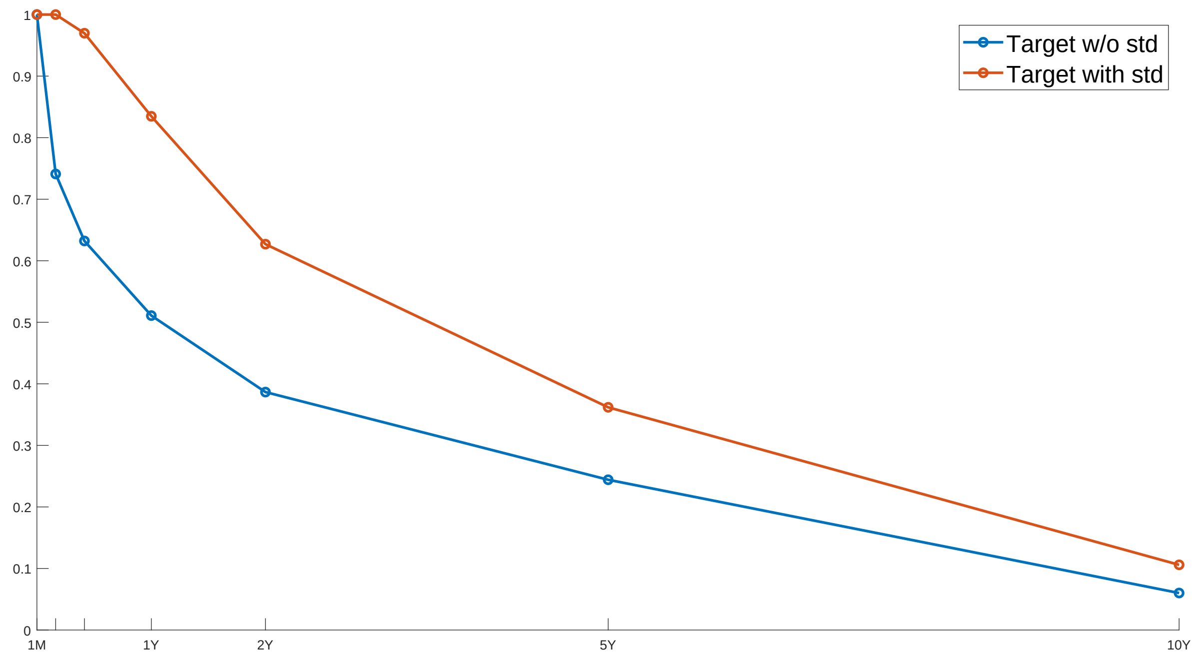
effect on 10-year OIS to capture a factor that mainly influence sovereign yield:

$$U'_{\cdot,4}\Lambda_{\cdot,7} = 0$$

Second, we impose that country risk factor has the smallest variance in the pre-crisis period (January 2002-7 August 2008), as done for the QE/QT factor. This restriction is similar to what done by Motto and Özen, 2022.

D Target factor loadings

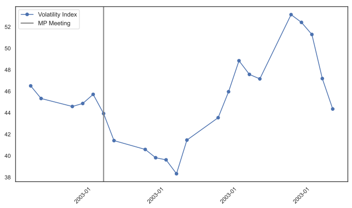
Figure D.4: PRESS RELEASE WINDOW



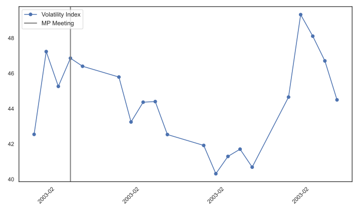
Notes: Figure D.4 reports the loadings of the Target factor as in Altavilla et al. (2019) (in blue) versus the loading of the same factor extracted with the standardisation of market surprises.

E VSTOXX in periods of high volatility

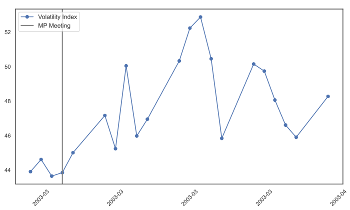
Figure E.5: Euro Stoxx Volatility Index for MP Meeting Dates 2003-2009



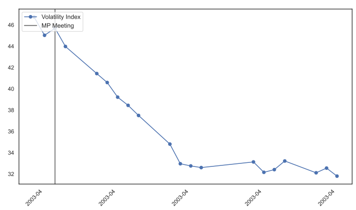
(a) MP Meeting Date: 2003-01-09



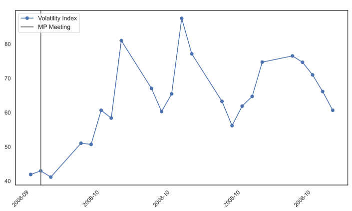
(b) MP Meeting Date: 2003-02-06



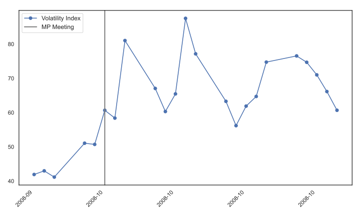
(c) MP Meeting Date: 2003-03-06



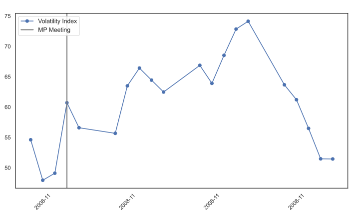
(d) MP Meeting Date: 2003-04-03



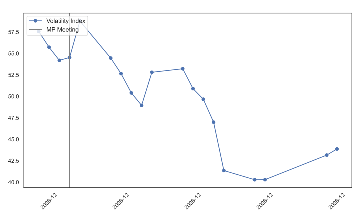
(e) MP Meeting Date: 2008-10-02



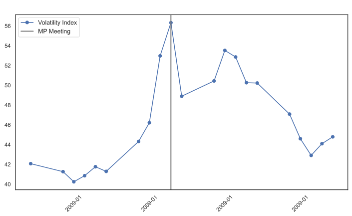
(f) MP Meeting Date: 2008-10-08



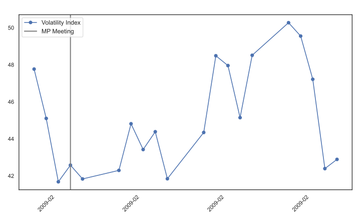
(g) MP Meeting Date: 2008-11-06



(h) MP Meeting Date: 2008-12-04



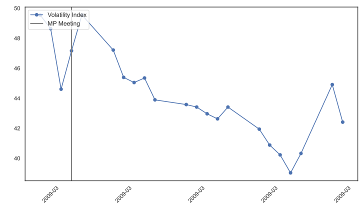
(i) MP Meeting Date: 2009-01-15



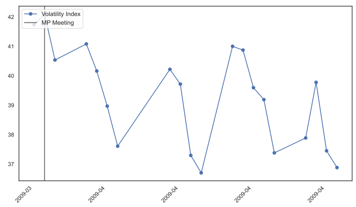
(j) MP Meeting Date: 2009-02-05

Notes: The figure displays the Euro Stoxx Volatility Index dynamics for the specified monetary policy meeting dates. Each subplot report the volatility for the month of the MP meeting.

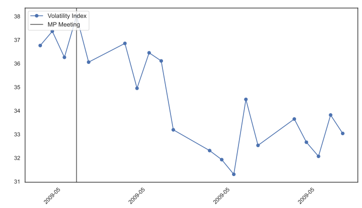
Figure E.6: Euro Stoxx Volatility Index for MP Meeting Dates 2009-2011



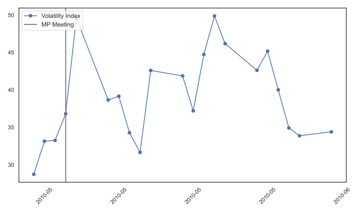
(a) MP Meeting Date: 2009-03-05



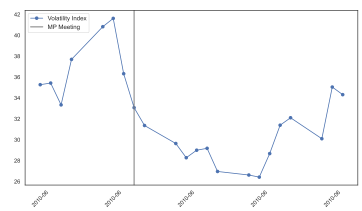
(b) MP Meeting Date: 2009-04-02



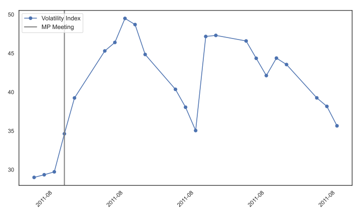
(c) MP Meeting Date: 2009-05-07



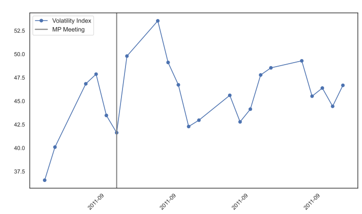
(d) MP Meeting Date: 2010-05-06



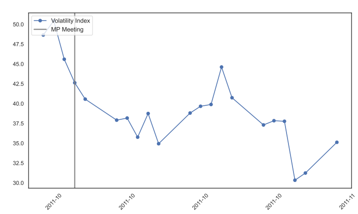
(e) MP Meeting Date: 2010-06-10



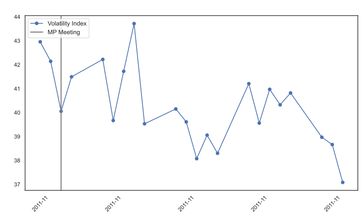
(f) MP Meeting Date: 2011-08-04



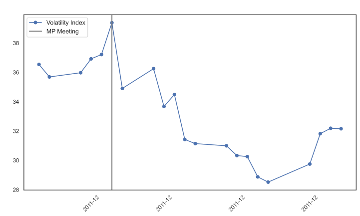
(g) MP Meeting Date: 2011-09-08



(h) MP Meeting Date: 2011-10-06



(i) MP Meeting Date: 2011-11-03



(j) MP Meeting Date: 2011-12-08

Notes: The figure displays the Euro Stoxx Volatility Index dynamics for the specified monetary policy meeting dates. Each subplot report the volatility for the month of the MP meeting.

F Information effects – Additional tables

Table F.6: Projection of yield curve surprises on forecasts - Linear specification

	(1) 1m-OIS	(2) 3m-OIS	(3) 6m-OIS	(4) 1y-OIS	(5) 2y-OIS	(6) 5y-OIS	(7) 10y-OIS
$MRO_{q=0}$	0.112	0.206	0.255	0.231	0.220	0.487	0.403*
	(0.245)	(0.264)	(0.314)	(0.389)	(0.396)	(0.393)	(0.241)
$\Delta MRO_{q=0}$	-5.036**	-4.497*	-4.820*	-3.947	-3.340	-1.175	0.390
	(2.419)	(2.438)	(2.529)	(2.729)	(2.730)	(2.355)	(1.395)
$HICP_{q=1}$	0.074	0.191	-0.229	-0.497	-1.430	-2.122	-0.708
	(1.023)	(0.999)	(1.202)	(1.546)	(1.634)	(1.558)	(1.146)
$GDP_{q=0}$	-1.779	-1.222	-1.219	-0.804	0.630	2.262	1.182
	(1.383)	(1.538)	(1.755)	(2.239)	(2.455)	(2.347)	(1.538)
$GDP_{q=2}$	2.768	1.257	0.791	0.563	-1.331	-2.342	-2.705
	(2.674)	(2.194)	(2.408)	(3.171)	(3.525)	(3.138)	(2.234)
$GDP_{y=0}$	0.399*	0.400*	0.457*	0.402	0.312	-0.008	-0.139
	(0.202)	(0.228)	(0.238)	(0.286)	(0.338)	(0.334)	(0.275)
$HICP_{y=0}$	0.009	0.248	0.523	0.471	0.693	0.963	0.324
	(1.178)	(0.945)	(1.018)	(1.255)	(1.326)	(1.287)	(0.907)
$HICP_{y=1}$	-2.401*	-3.185**	-2.974	-3.015	-2.513	-2.117	-1.917
	(1.315)	(1.565)	(1.820)	(2.189)	(2.409)	(2.389)	(1.748)
$\Delta HICP_{y=0}$	1.709*	1.272	1.463	1.364	0.789	0.629	1.064
	(0.928)	(0.947)	(1.045)	(1.247)	(1.302)	(1.267)	(0.899)
$HICP^{ECB}_{q=0}$	1.268	0.681	0.961	1.329	2.370	3.391*	1.808
	(0.895)	(1.072)	(1.317)	(1.854)	(2.050)	(1.954)	(1.351)
$\Delta HICP^{ECB}_{q=0}$	-1.292**	-0.625	-1.088	-0.671	-0.375	0.461	1.077
	(0.583)	(0.621)	(0.741)	(0.991)	(1.108)	(1.163)	(0.925)
$GDP^{ECB}_{y=0}$	-0.047	0.012	0.049	0.168	-0.039	-0.162	0.045
	(0.200)	(0.231)	(0.295)	(0.407)	(0.500)	(0.440)	(0.349)
$HICP^{ECB}_{y=0}$	-1.163	-0.491	-0.590	-0.675	-1.537	-2.628	-1.390
	(1.045)	(1.230)	(1.518)	(2.098)	(2.283)	(2.137)	(1.453)
Constant	2.657	3.579*	3.417	3.848	4.371	4.370	3.706*
	(1.775)	(1.929)	(2.258)	(2.668)	(2.920)	(2.819)	(2.176)
$\mathcal{R}^2_{adj}$	0.074	0.057	0.060	0.023	0.017	0.008	0.015
N	197	197	197	197	197	197	197

Notes: The table reports the linear information effects where we regress market suprises on forecasts, without controlling for non-linear info.

Table F.6: Projection of spreads, exchange rates and stock market surprises on forecasts - Linear specification

	(1) 2y-Spread b/(se)	(2) 5y-Spread b/(se)	(3) 10y-Spread b/(se)	(4) EURGBP b/(se)	(5) EURJPY b/(se)	(6) EURUSD b/(se)	(7) STOXX50 b/(se)
$MRO_{q=0}$	0.148	-0.495	-0.474	0.040	0.053	0.081*	-0.007
	(0.553)	(0.588)	(0.614)	(0.035)	(0.043)	(0.046)	(0.066)
$\Delta MRO_{q=0}$	-2.512	-5.853***	-4.918**	0.064	0.274*	0.186	0.961***
	(1.987)	(2.173)	(2.231)	(0.132)	(0.152)	(0.168)	(0.249)
$HICP_{q=1}$	1.839*	1.923	1.540	-0.032	-0.091	-0.091	-0.052
	(1.097)	(1.198)	(1.124)	(0.163)	(0.185)	(0.215)	(0.271)
$GDP_{q=0}$	-0.898	-2.574	-3.108	-0.094	0.183	-0.090	0.399
	(2.980)	(3.048)	(2.664)	(0.214)	(0.210)	(0.236)	(0.352)
$GDP_{q=2}$	-1.164	1.038	1.618	0.256	-0.189	0.183	-0.434
	(3.233)	(3.108)	(3.064)	(0.238)	(0.281)	(0.302)	(0.509)
$GDP_{y=0}$	0.208	-0.048	0.005	-0.038	-0.025	-0.028	0.036
	(0.315)	(0.441)	(0.384)	(0.031)	(0.043)	(0.036)	(0.069)
$HICP_{y=0}$	-0.943	-1.323	-1.541	-0.027	0.171	0.101	-0.003
	(1.141)	(1.092)	(1.068)	(0.131)	(0.152)	(0.175)	(0.246)
$HICP_{y=1}$	-0.002	3.324	3.913	-0.029	-0.452	-0.340	-0.011
	(2.599)	(2.375)	(2.644)	(0.284)	(0.303)	(0.343)	(0.467)
$\Delta HICP_{y=0}$	0.685	2.036	1.058	-0.024	-0.052	0.068	-0.242*
	(1.134)	(1.322)	(0.961)	(0.114)	(0.118)	(0.130)	(0.142)
$HICP^{ECB}_{q=0}$	-0.233	-0.005	-1.852	-0.043	-0.037	0.043	-0.125
	(2.378)	(2.456)	(2.236)	(0.213)	(0.218)	(0.229)	(0.318)
$\Delta HICP^{ECB}_{q=0}$	-0.406	0.836	1.161	0.072	0.283**	0.128	-0.017
	(1.379)	(1.508)	(1.205)	(0.125)	(0.126)	(0.124)	(0.172)
$GDP^{ECB}_{y=0}$	-0.206	0.033	0.047	0.010	0.031	0.045	-0.031
	(0.524)	(0.536)	(0.491)	(0.058)	(0.053)	(0.052)	(0.078)
$HICP^{ECB}_{y=0}$	0.141	-0.103	1.692	0.079	0.084	-0.018	0.162
	(2.808)	(2.619)	(2.292)	(0.224)	(0.230)	(0.247)	(0.346)
Constant	-1.286	-5.583*	-5.519	0.026	0.536	0.348	0.034
	(3.422)	(3.319)	(3.829)	(0.361)	(0.414)	(0.466)	(0.673)
$\mathcal{R}^2_{adj}$	-0.022	0.020	0.003	-0.024	-0.002	-0.022	0.026
N	197	197	197	197	197	197	197

Notes: The table reports the linear information effects where we regress market suprises on forecasts, without controlling for non-linear information effects.

Table F.6: Projection of spreads, exchange rates and stock market surprises on forecasts - Non-linear specification

	(1) 2y-Spread b/(se)	(2) 5y-Spread b/(se)	(3) 10y-Spread b/(se)	(4) EURGBP b/(se)	(5) EURJPY b/(se)	(6) EURUSD b/(se)	(7) STOXX50 b/(se)
$MRO_{q=0}$	0.256	-0.275	-0.394	0.050	0.023	0.062	-0.060
	(0.524)	(0.575)	(0.543)	(0.039)	(0.048)	(0.053)	(0.068)
$\Delta MRO_{q=0}$	-8.910**	-12.285**	-11.156*	0.282	0.257	0.189	1.069**
	(3.775)	(5.274)	(5.658)	(0.205)	(0.225)	(0.275)	(0.512)
$HICP_{q=1}$	1.045	0.967	0.550	0.001	-0.002	-0.022	0.141
	(1.275)	(1.584)	(1.385)	(0.193)	(0.216)	(0.258)	(0.310)
$GDP_{q=0}$	-0.089	-4.143	-4.572	-0.100	0.281	0.010	0.390
	(3.912)	(4.467)	(4.071)	(0.241)	(0.260)	(0.281)	(0.398)
$GDP_{q=2}$	-1.116	0.274	2.022	0.023	-0.166	0.162	0.374
	(3.790)	(4.181)	(3.467)	(0.285)	(0.351)	(0.384)	(0.463)
$GDP_{y=0}$	0.105	0.109	-0.069	-0.007	-0.015	-0.012	0.015
	(0.318)	(0.524)	(0.396)	(0.033)	(0.047)	(0.038)	(0.076)
$HICP_{y=0}$	-0.298	-0.906	-1.478	-0.044	0.123	0.060	-0.132
	(1.437)	(1.536)	(1.481)	(0.174)	(0.194)	(0.235)	(0.304)
$HICP_{y=1}$	0.377	4.170	6.361	-0.133	-0.440	-0.328	-0.016
	(3.098)	(3.579)	(3.958)	(0.318)	(0.350)	(0.389)	(0.559)
$\Delta HICP_{y=0}$	1.952	2.658	1.845	-0.072	-0.094	-0.020	-0.098
	(1.490)	(1.826)	(1.356)	(0.156)	(0.169)	(0.183)	(0.163)
$HICP^{ECB}_{q=0}$	0.812	-1.548	-2.744	0.117	-0.015	0.072	-0.400
	(2.974)	(3.060)	(2.883)	(0.241)	(0.324)	(0.329)	(0.367)
$\Delta HICP^{ECB}_{q=0}$	-0.139	2.258	2.593	-0.062	0.280	0.119	0.089
	(1.878)	(1.887)	(1.656)	(0.150)	(0.191)	(0.187)	(0.169)
$GDP^{ECB}_{y=0}$	-0.220	0.133	0.222	-0.016	0.007	0.016	-0.049
	(0.538)	(0.599)	(0.563)	(0.054)	(0.056)	(0.052)	(0.084)
$HICP^{ECB}_{y=0}$	-1.279	1.098	2.156	-0.057	0.073	-0.029	0.496
	(3.391)	(3.236)	(2.884)	(0.252)	(0.335)	(0.347)	(0.398)
$I(index) * MRO_{q=0}$	0.154	-0.666	-1.224	-0.033	0.201	-0.051	0.124
	(2.387)	(1.545)	(0.873)	(0.110)	(0.204)	(0.152)	(0.315)
$I(index) * \Delta MRO_{q=0}$	9.611**	8.510	8.686	-0.168	0.246	0.194	0.579
	(4.424)	(5.878)	(5.503)	(0.266)	(0.357)	(0.341)	(0.713)
$I(index) * HICP_{q=1}$	9.200	13.305*	-0.396	0.667	0.851	0.993	-0.581
	(9.856)	(7.693)	(4.797)	(0.556)	(0.898)	(0.604)	(1.311)
$I(index) * GDP_{q=0}$	5.485	17.812***	11.365**	-0.811	-0.933*	-0.835*	0.218
	(6.048)	(6.149)	(4.395)	(0.623)	(0.510)	(0.493)	(1.526)
$I(index) * GDP_{q=2}$	-22.679**	-26.069***	-14.598***	3.001***	1.816*	2.578***	-0.770
	(10.545)	(8.380)	(3.956)	(1.149)	(1.073)	(0.951)	(2.901)
$I(index) * GDP_{y=0}$	0.386	-2.723*	0.924	-0.500***	-0.444**	-0.612***	-0.214
	(2.101)	(1.618)	(1.010)	(0.183)	(0.206)	(0.148)	(0.335)
$I(index) * HICP_{y=0}$	-11.411*	-11.193**	-2.577	0.476	0.110	0.337	1.029
	(5.971)	(4.874)	(3.079)	(0.341)	(0.481)	(0.387)	(0.696)
$I(index) * HICP_{y=1}$	8.342	5.965	6.428***	-1.525**	-1.318**	-1.487***	-0.448
	(5.323)	(4.124)	(2.250)	(0.632)	(0.575)	(0.444)	(1.172)
$I(index) * \Delta HICP_{y=0}$	-0.949	-0.317	-1.247	-0.213	-0.170	-0.148	-0.780*
	(2.241)	(2.544)	(1.577)	(0.240)	(0.258)	(0.243)	(0.470)
$I(index) * HICP^{ECB}_{q=0}$	-3.930	3.590	0.002	0.261	-0.065	-0.097	1.149
	(5.474)	(5.534)	(3.718)	(0.576)	(0.562)	(0.605)	(0.861)
$I(index) * \Delta HICP^{ECB}_{q=0}$	-7.466**	-13.293***	-6.790**	-0.425	-0.323	-0.605	-0.678
	(3.653)	(4.206)	(3.027)	(0.370)	(0.309)	(0.389)	(0.539)
$I(index) * GDP^{ECB}_{y=0}$	4.839*	5.439**	0.172	0.652**	0.370*	0.474*	0.237
	(2.512)	(2.519)	(1.497)	(0.279)	(0.209)	(0.279)	(0.437)
$I(index) * HICP^{ECB}_{y=0}$	3.024	-5.238	0.763	-0.668	-0.149	-0.218	-1.627*
	(5.982)	(6.224)	(4.020)	(0.641)	(0.596)	(0.673)	(0.948)
$Constant$	-1.794	-5.656	-7.565	0.214	0.441	0.265	-0.302
	(3.793)	(4.334)	(4.667)	(0.407)	(0.466)	(0.521)	(0.768)
$\mathcal{R}^2_{adj}$	0.021	0.053	-0.001	-0.022	-0.041	-0.061	0.038
N	197	197	197	197	197	197	197

Notes: The table reports the non-linear information effects specification for spreads, exchange rates and stock market surprises.

Table F.6: Projection of yield curve surprises on forecasts - Lasso over larger set of forecasts

	(1) 1m-OIS	(2) 3m-OIS	(3) 6m-OIS	(4) 1y-OIS	(5) 2y-OIS	(6) 5y-OIS	(7) 10y-OIS
$\Delta HICP^{ECB}_{q=4}$	-2.623**	-1.869	-2.471	-3.024			
	(1.064)	(1.663)	(1.778)	(2.277)			
$\Delta MRO_{q=1}$	-3.135**						
	(1.518)						
$\Delta HICP_{q=4}$	-3.565						
	(2.200)						
$\Delta MRO_{q=0}$		-2.740	-2.992*	-4.637*	-3.150		
		(1.787)	(1.770)	(2.461)	(2.504)		
$\Delta GDP_{q=4}$		-6.221					
		(3.880)					
$\Delta GDP^{ECB}_{q=4}$			-7.481	-13.089**	-8.300		
			(4.930)	(6.575)	(5.606)		
$HICP^{ECB}_{y=0}$			0.530*				
			(0.318)				
$HICP^{ECB}_{q=4}$				1.123***	1.126**	1.013**	0.722***
				(0.431)	(0.449)	(0.423)	(0.415)
$\Delta HICP^{ECB}_{y=0}$				2.325**			
				(1.010)			
$\Delta MRO_{q=3}$				3.790			
				(2.527)			
$\Delta HICP_{q=0}$				-0.439	-0.751	-0.827	
				(0.430)	(0.574)	(0.505)	
$GDP_{q=4}$					-1.665		
					(3.019)		
$\Delta GDP^{ECB}_{q=0}$							3.641**
							(1.824)
$\Delta HICP^{ECB}_{q=3}$						1.999	1.421
						(1.219)	(1.003)
$\Delta HICP_{q=2}$							1.843*
							(1.052)
$GDP_{q=2}$							-6.593**
							(3.298)
$HICP_{y=1}$							-1.134
							(0.731)
$Constant$	0.007	-0.023	-0.299	0.133	1.136	0.697	1.390
	(0.189)	(0.194)	(0.262)	(0.641)	(1.277)	(0.808)	(1.238)
$\mathcal{R}^2_{adj}$	0.124	0.081	0.090	0.097	0.063	0.056	0.111
N	197	197	197	197	197	197	197

Notes: The table reports the linear information effects where we regress market suprises on forecasts. We use lasso over a larger set of forecasts with respect to the baseline. Specifically, we include forecast for longer horizons (up to four quarters for quarterly forecasts and two years for yearly forecasts). By including a larger set of forecasts, especially those at longer horizons, we are able to capture more than 11% of the variability of the 10y-OIS and larger variability for longer maturities of the yield curve.

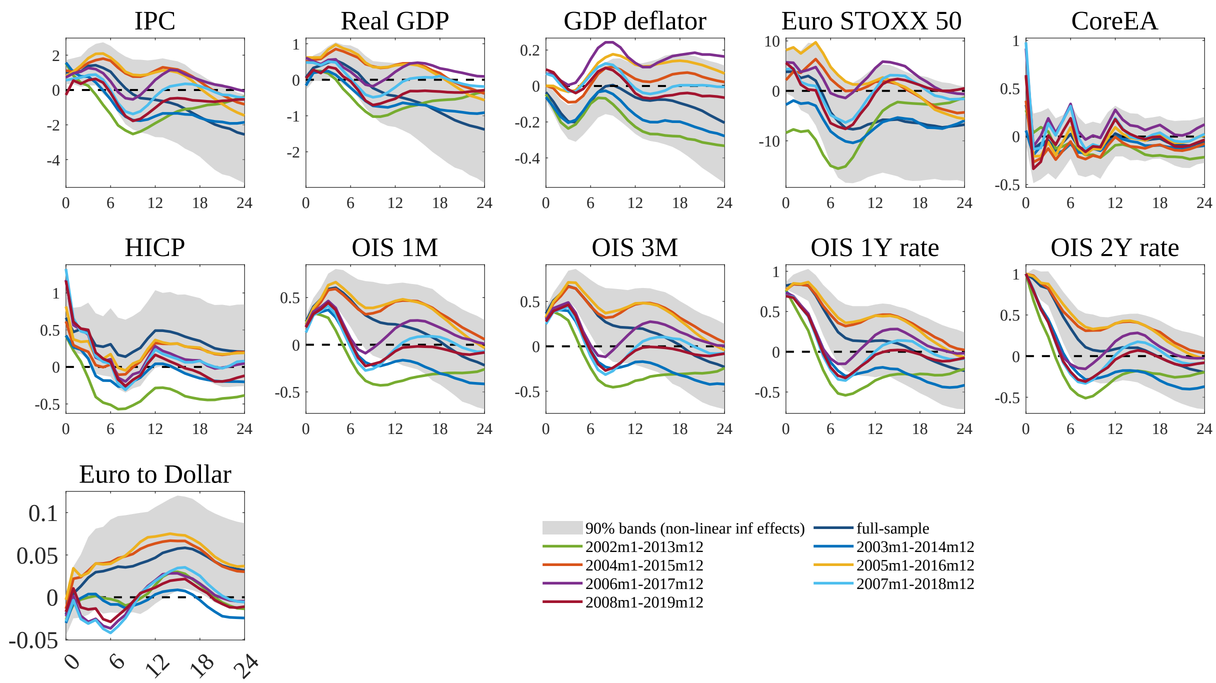
Table F.6: Projection of spreads, exchange rates and stock market surprises on forecasts - Lasso over larger set of forecasts

	(1) 2y-Spread b/(se)	(2) 5y-Spread b/(se)	(3) 10y-Spread b/(se)	(4) EURGBP b/(se)	(5) EURJPY b/(se)	(6) EURUSD b/(se)	(7) STOXX50 b/(se)
$HICP_{q=0}$	0.861***						
	(0.286)						
$\Delta GDP^{ECB}_{q=3}$		-8.520					
		(7.622)					
$\Delta HICP^{ECB}_{q=3}$		3.354**					
		(1.633)					
$\Delta MRO_{q=0}$		-3.258*	-4.143*				0.657***
		(1.823)	(2.127)				(0.215)
$\Delta MRO_{q=4}$		-1.213					
		(1.496)					
$GDP_{q=1}$		-1.947					
		(2.387)					
$\Delta GDP_{q=3}$		-9.544					
		(8.812)					
$HICP_{q=1}$		1.166***					
		(0.432)					
$\Delta GDP^{ECB}_{q=0}$				0.719***			
				(0.247)			
$\Delta HICP_{q=2}$						0.371***	
						(0.136)	
$\Delta MRO_{q=2}$							0.341*
							(0.194)
Constant	-1.667***	-1.540*	-0.090	-0.004	-0.015	-0.031	-0.093**
	(0.461)	(0.816)	(0.310)	(0.026)	(0.033)	(0.034)	(0.046)
$\mathcal{R}^2_{adj}$	0.025	0.077	0.021	0.050	0.000	0.024	0.060
N	197	197	197	197	197	197	197

Notes: The table reports the linear information effects where we regress market suprises on forecasts. By using Lasso over a lrger set of forecasts, we have qualitatively the same results as the baseline where we do not explain a large variability of the exchange rates and spread surprises.

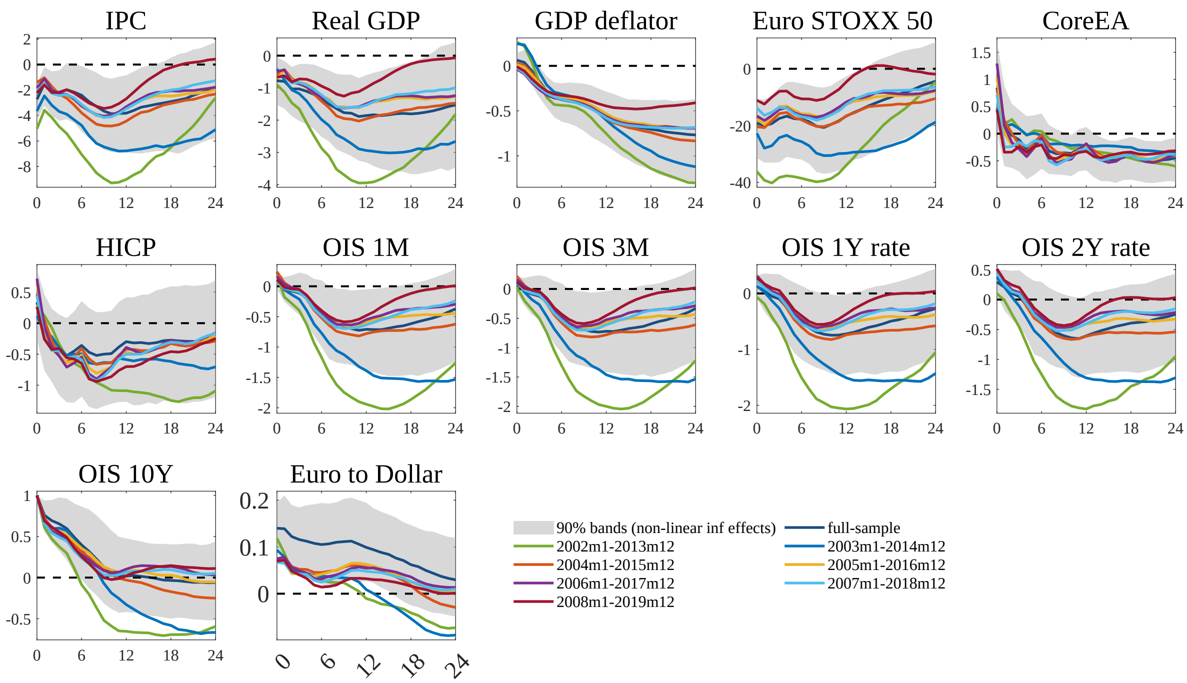
G Rolling subsamples for IRFs

Figure G.7: Forward Guidance factor – rolling sample



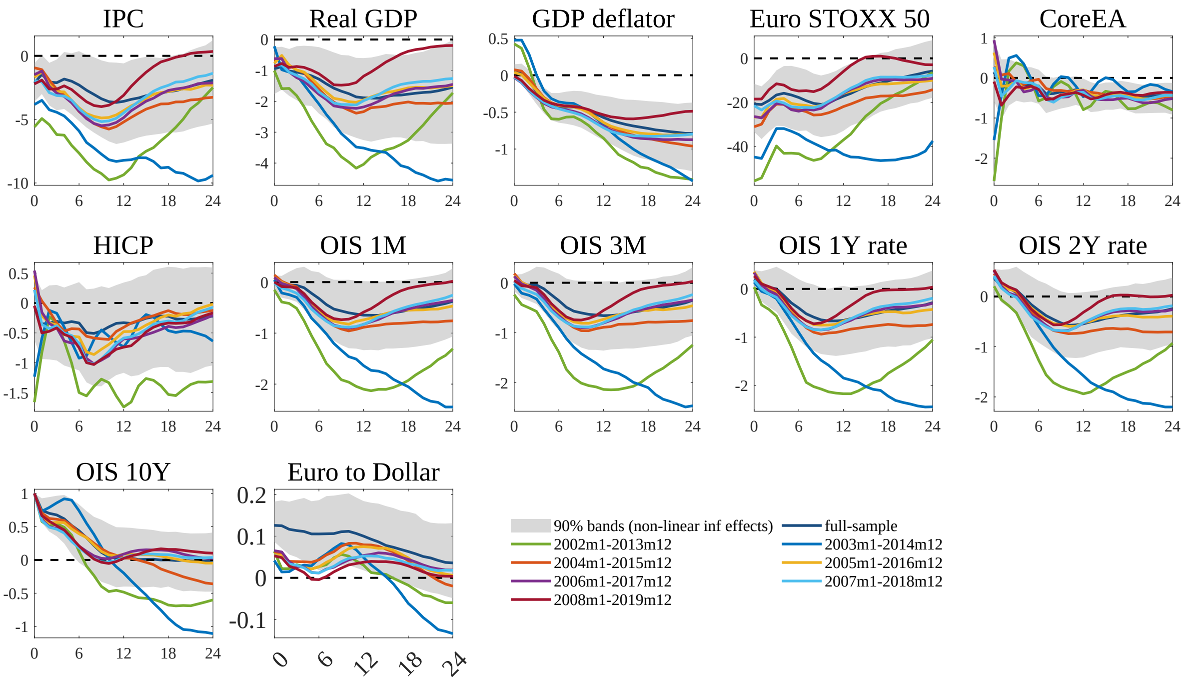
Notes: The figure reports the IRFs to a forward guidance shock on the baseline sample and on a set of rolling subsamples. The shock is identified with the informationally robust forward guidance factor, corrected for nonlinear information effects, and normalised to induce a 100 basis points increase of the 2y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure G.8: QE factor – rolling sample – no info



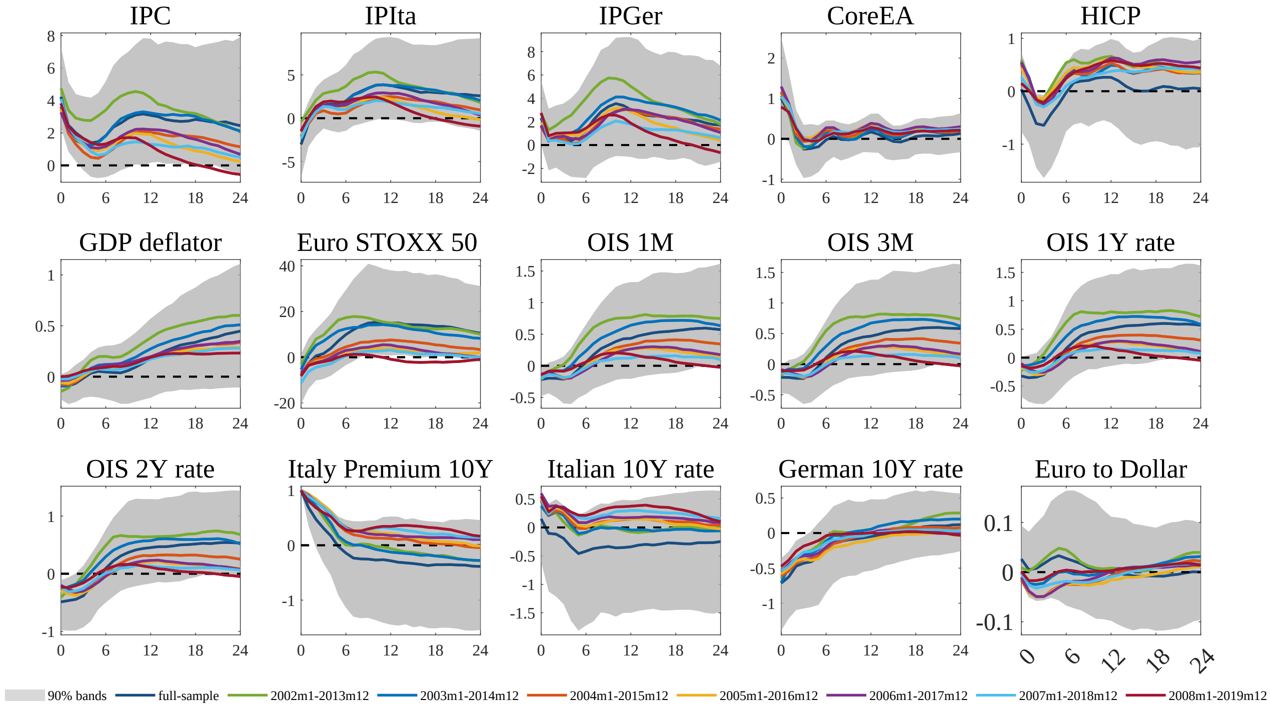
Notes: The figure reports the IRFs to a Quantitative Tightening shock on the baseline sample and on a set of rolling subsamples. The shock is identified with the QE/QT factor, without any correction for information effects, and normalised to induce a 100 basis points increase of the 10y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure G.9: QE factor – rolling sample – info



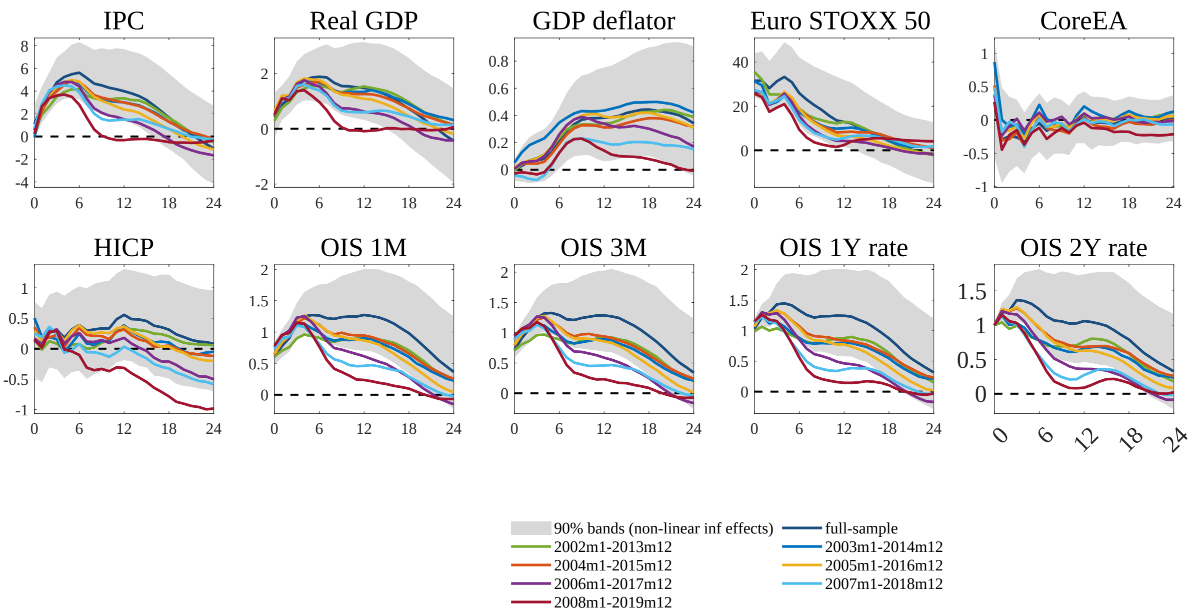
Notes: The figure reports the IRFs to a Quantitative Tightening shock on the baseline sample and on a set of rolling subsamples. The shock is identified with the QE/QT factor, corrected for nonlinear information effects, and normalised to induce a 100 basis points increase of the 10y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure G.10: Asymmetric country risk factor – rolling sample



Notes: The figure reports the IRFs to a asymmetric country risk shock on the baseline sample and on a set of rolling subsamples. The shock is identified with the asymmetric country risk factor, corrected for nonlinear information effects, and normalised to induce a 100 basis points increase of the spread between the 10Y Italian government bond yield and the 10Y German government bond yield. The grey areas are 90% coverage bands of the baseline specification.

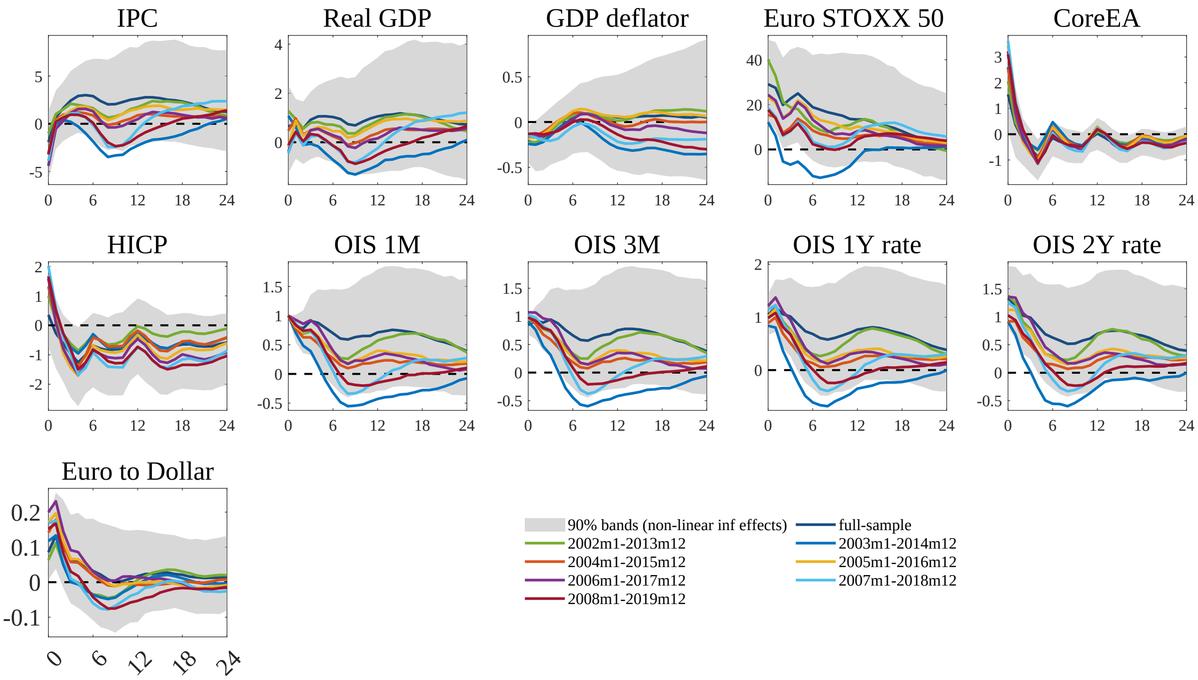
Figure G.11: Information factor – rolling sample



Notes: The figure reports the IRFs to an 'information shock' on the baseline sample and on a set of rolling subsamples. The shock is identified with an information factor defined as the sum of the first two principal components of the fitted values of the non-linear information effects regressions, and normalised to induce a 100 basis points increase of the 2y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

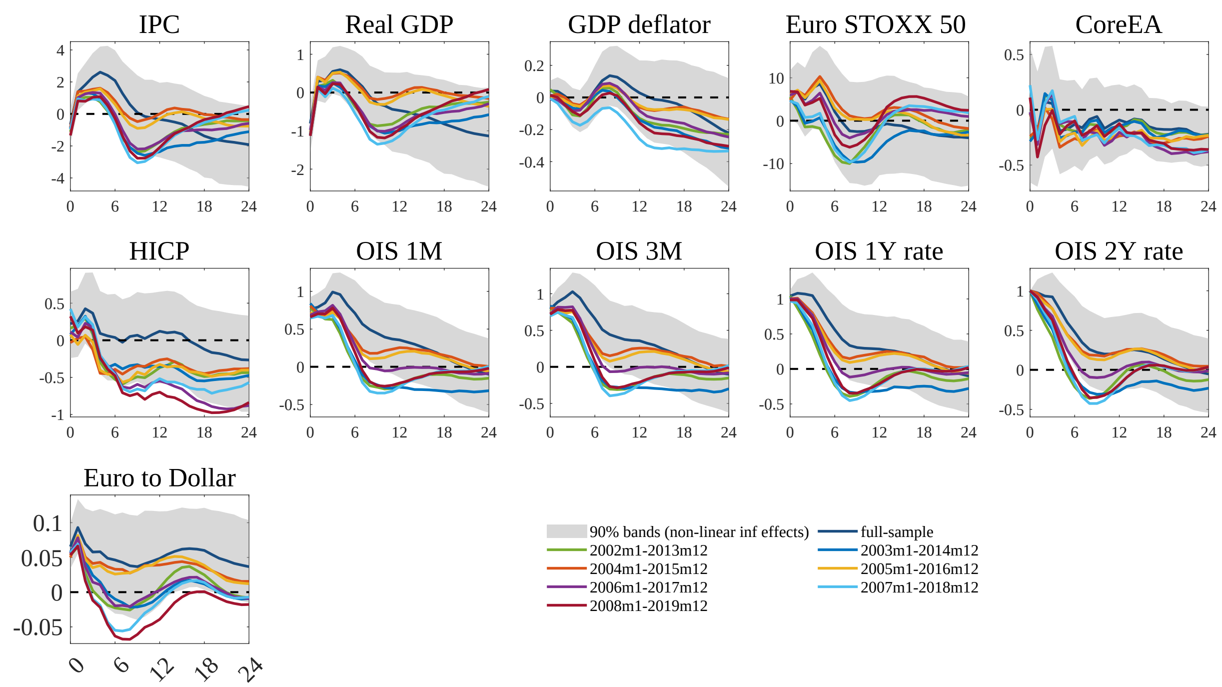
H Rolling subsamples for IRFs Altavilla et al. (2019)

Figure H.12: Target factor Altavilla et al. (2019) – rolling sample



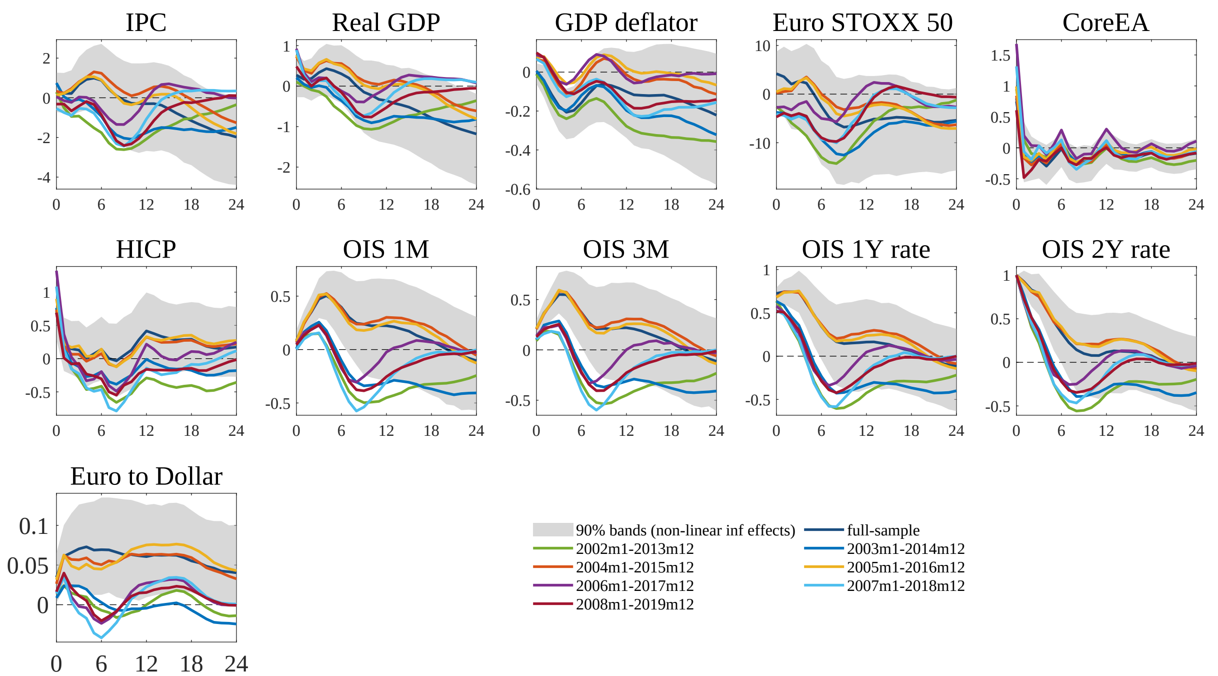
Notes: The figure reports the IRFs to a conventional monetary policy shock on the baseline sample and on a set of rolling subsamples. The shock is identified with the target factor of Altavilla et al. (2019), and normalised to induce a 100 basis points increase of the 1m-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure H.13: TIMING FACTOR ALTAVILLA ET AL. (2019) – ROLLING SAMPLE



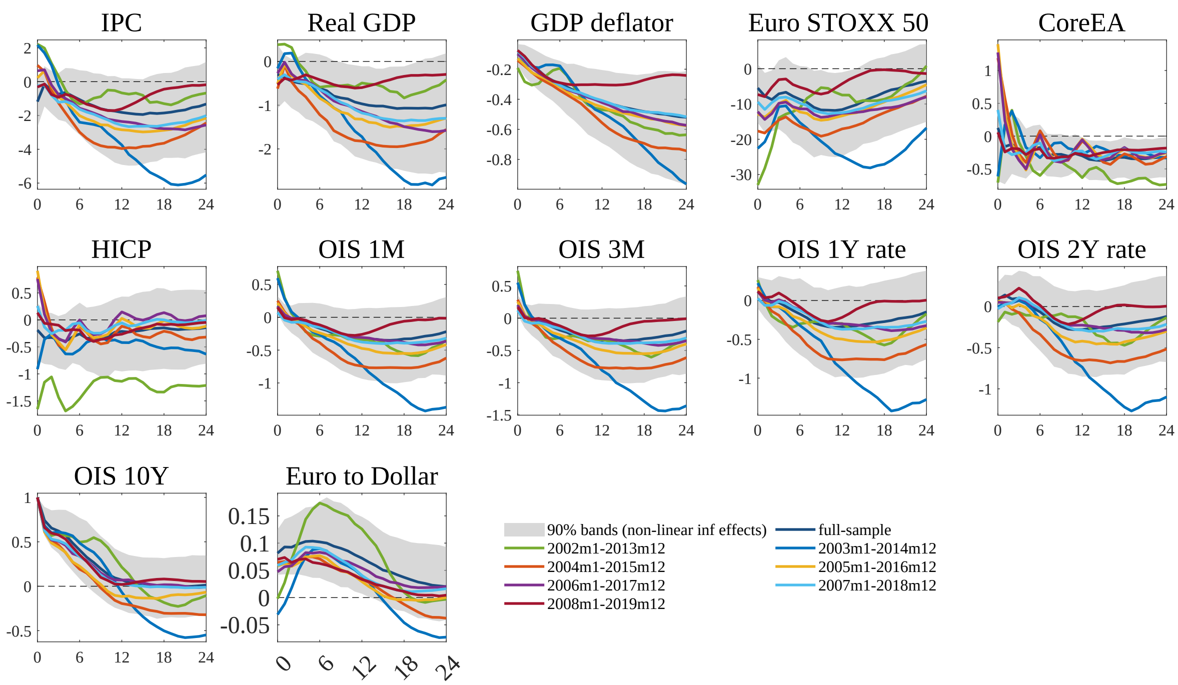
Notes: The figure reports the IRFs to a shock on the 2y-OIS rate on the baseline sample and on a set of rolling subsamples. The shock is identified with the timing factor of Altavilla et al. (2019), and normalised to induce a 100 basis points increase of the 2y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure H.14: Forward guidance factor Altavilla et al. (2019) – rolling sample



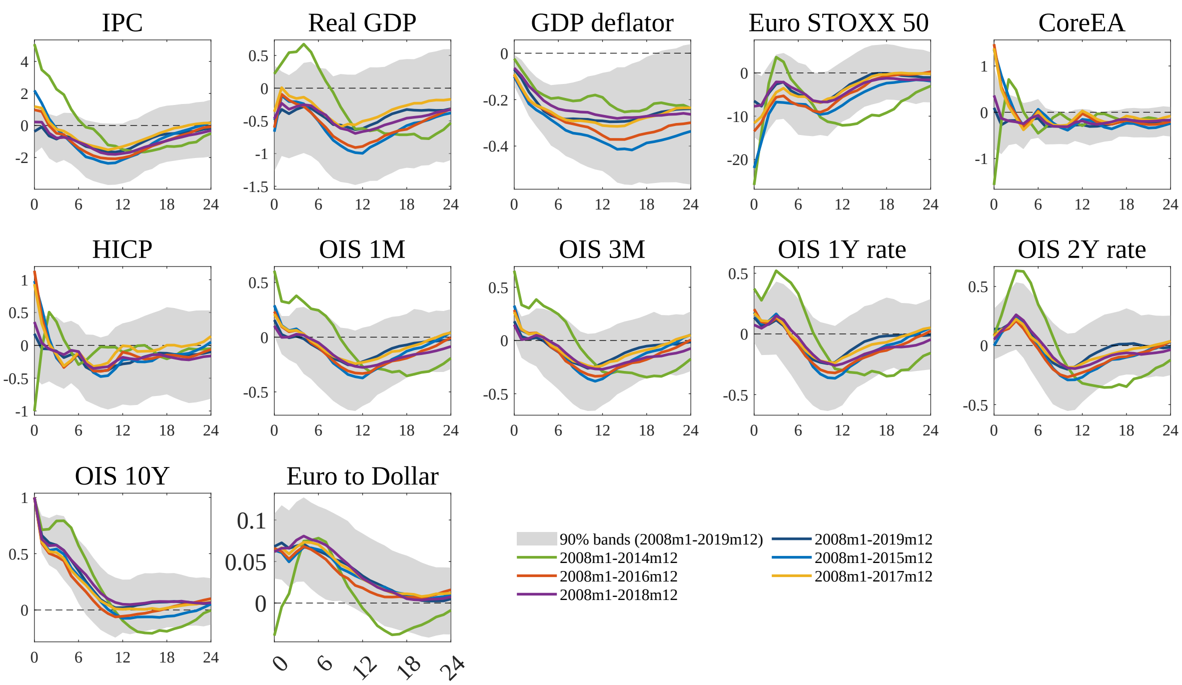
Notes: The figure reports the IRFs to a shock on the 2y-OIS rate on the baseline sample and on a set of rolling subsamples. The shock is identified with the forward guidance factor of Altavilla et al. (2019), and normalised to induce a 100 basis points increase of the 2y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

Figure H.15: Quantitative easing/tightening factor Altavilla et al. (2019) – rolling sample



Notes: The figure reports the IRFs to a shock on the 10y-OIS rate on the baseline sample and on a set of rolling subsamples. The shock is identified with the QE/QT factor of Altavilla et al. (2019), and normalised to induce a 100 basis points increase of the 10y-OIS rate. The grey areas are 90% coverage bands of the baseline specification.

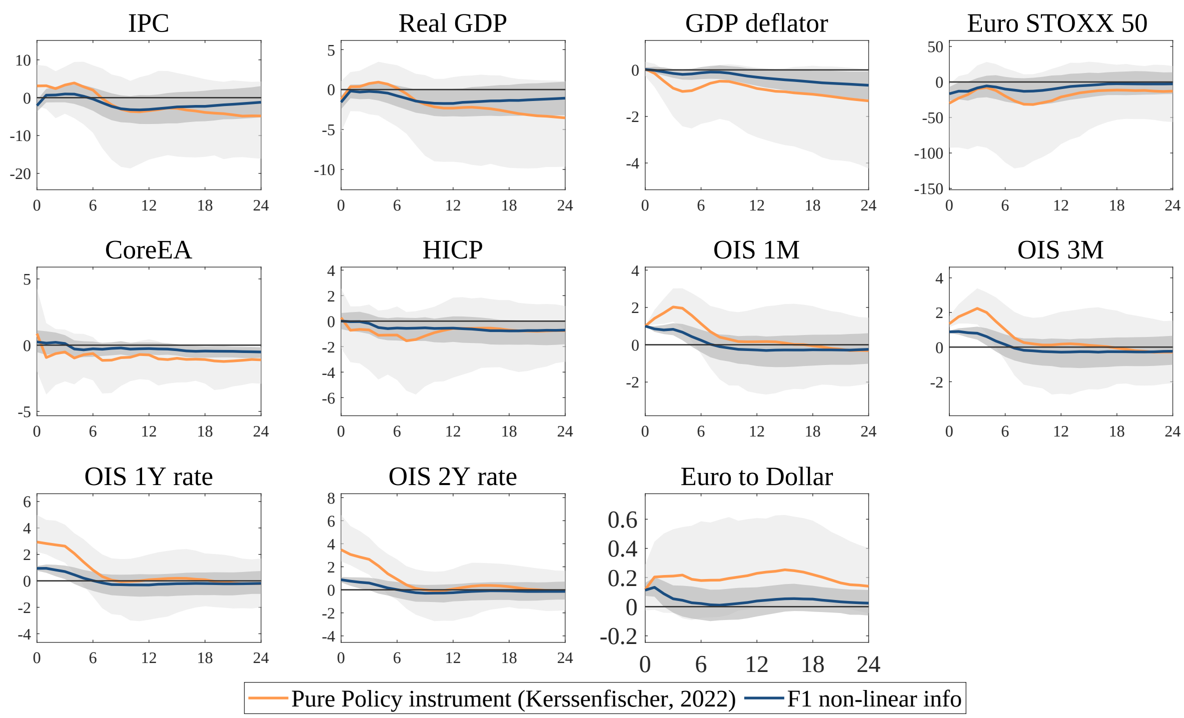
Figure H.16: Quantitative easing/tightening (Altavilla et al. (2019) factor) – extending samples



Notes: The figure reports the IRFs to a Quantitative Tightening shock, normalised to induce a 100 basis points tightening in the 10y-OIS, and a set of subsamples starting from 2008. The shock is identified with thet QE/QT factor of Altavilla et al. (2019), and normalised to induce a 100 basis points increase in the 10y-OIS rate.

I A comparison with Kerssenfischer (2022)

Figure I.17: Conventional monetary policy shock – comparison with Kerssenfischer (2022)



Notes: The figure reports the IRFs to a conventional monetary policy shock, normalised to induce a 100 basis points increase of the 1m-OIS rate. In amber, it reports the responses obtained with the pure policy instrument identified by Kerssenfischer (2022). In blue, it reports the IRFs by using the informationally robust F1 factor. The grey areas are 90% coverage bands. The sample considered is 2002m3-2019m12.

J Variance decomposition – Additional tables

Table J.17: Variance Decomposition at a short run horizon

Variables	*Target*	*Forward Guidance*	*QE*	*Asymmetric Country Risk*	*Information*
IP	5.67	14.55	5.46	9.78	13.33
	(3.67, 8.23)	(8.43, 20.51)	(2.73, 9.14)	(5.88, 13.86)	(8.60, 18.90)
Real GDP	5.54	14.24	6.83	–	7.86
	(3.48, 8.65)	(3.34, 11.44)	(1.59, 15.35)	–	(4.48, 11.81)
Stock Market	4.49	9.88	11.38	5.69	37.77
	(2.86, 6.70)	(5.66, 13.97)	(7.43, 15.59)	(2.55, 8.50)	(28.96, 45.40)
HICP	3.02	7.01	2.63	3.28	3.95
	(1.73, 4.79)	(4.56, 9.73)	(1.36, 4.18)	(1.77, 5.26)	(1.90, 6.33)
1m-OIS	16.92	20.19	5.24	8.61	26.24
	(11.69, 22.26)	(13.08, 27.78)	(1.86, 10.10)	(3.67, 13.87)	(19.14, 34.27)
1y-OIS	12.23	39.40	5.12	8.12	31.62
	(8.29, 16.12)	(29.46, 46.90)	(2.10, 8.86)	(3.80, 12.13)	(23.48, 39.60)
2y-OIS	8.87	43.14	5.71	8.06	27.16
	(5.93, 12.40)	(33.53, 50.45)	(2.77, 9.32)	(4.07, 12.41)	(19.29, 34.25)
10y-OIS	–	–	17.86	–	–
	–	–	(12.72, 22.87)	–	–
Spread 10Y	–	–	–	10.32	–
	–	–	–	(6.65, 15.65)	–
IP Italy	–	–	–	5.61	–
	–	–	–	(3.07, 8.45)	–
IP Germany	–	–	–	4.26	–
	–	–	–	(2.36, 6.69)	–

Notes: The table reports the percentages shares of the variance for each variable considered as due to each monetary policy shock, in the range of short-term frequencies (i.e. 2 and 16 months), following the following Forni et al. (2022). 68% confidence bands are reported in parenthesis.

Table J.17: VARIANCE DECOMPOSITION – OVERALL VARIANCE

Variables	*Target*	*Forward Guidance*	*QE*	*Asymmetric Country Risk*	*Information*
IP	3.16	7.36	9.45	7.52	23.99
	(1.25, 6.73)	(3.39, 12.90)	(3.89, 16.99)	(2.84, 13.38)	(15.70, 34.66)
Real GDP	4.71	9.29	13.79	–	14.82
	(1.56, 9.40)	(3.81, 16.06)	(6.60, 21.80)	–	(8.35, 23.02)
Stock Market	3.35	6.50	14.86	6.79	32.19
	(1.31, 6.78)	(2.45, 11.97)	(7.42, 22.44)	(2.70, 12.74)	(21.33, 43.89)
HICP	4.10	6.59	3.23	2.50	5.05
	(1.21, 8.66)	(3.41, 12.03)	(1.19, 7.70)	(1.23, 4.67)	(1.94, 11.82)
1m-OIS	4.72	8.62	7.12	5.24	44.42
	(2.70, 7.86)	(5.36, 12.90)	(1.89, 14.46)	(1.45, 10.21)	(32.89, 56.13)
1y-OIS	3.91	12.58	6.25	5.70	42.85
	(2.11, 6.70)	(8.47, 17.03)	(1.87, 12.63)	(1.80, 10.45)	(31.24, 54.25)
2y-OIS	3.58	15.10	5.38	5.61	40.21
	(1.78, 6.00)	(10.46, 19.55)	(1.99, 10.57)	(2.25, 10.22)	(29.20, 51.23)
10y-OIS	–	–	10.83	–	–
	–	–	(6.41, 15.72)	–	–
Spread 10Y	–	–	–	3.85	–
	–	–	–	(1.79, 7.01)	–
IP Italy	–	–	–	5.51	–
	–	–	–	(2.16, 10.95)	–
IP Germany	–	–	–	3.66	–
	–	–	–	(1.32, 8.34)	–

Notes: The table reports the percentages shares of the overall variance (i.e. 2+ months) for each variable considered as due to each monetary policy shock following the following Forni et al. (2022). 68% confidence bands are reported in parenthesis.

K List of 10 largest surprises in identified factor series

The tables below record the largest surprises in the four identified factors, presented in chronological order. Column 2 of each table records the magnitude of the surprise on the particular date. Column 3 contains any changes in the key interest rates of the ECB: the Main Refinancing Operations (MRO) rate, the Marginal Lending Facility (MLF) rate and the Deposit Facility (EDF) rate. Prior to the global financial crisis, in case of a change in the policy rate, all policy rates moved by the same magnitude. After October 2008, there were some instances where this was not the case. On such dates, we specify the rates which were changed. Column 4 provides a summary of the economic analysis mentioned in the Introductory Statement of the ECB president in the press conference held to announce the policy decision. The economic analysis typically contains details about real GDP growth and inflation as well as their outlook. Column 5 presents potential reasons for observing the large surprise. These combine insights from high frequency surprise data in OIS rates and sovereign bonds on policy announcement dates, the median expected MRO forecast data, and reading the transcripts of the Q&A session held with journalists on the day of the policy announcement after the ECB president's Introductory Statement. Forecasts of MRO rate are a measure of the expectations of financial markets prior to the monetary policy announcement. Journalists in the Q&A ask about the reaction of financial markets to the ECB's policy decision and statements. This corroborates our intuition about the surprise.

The transcripts of the press conference held on the day of the policy announcement are available on the ECB website.[8] They contain the Introductory Statement delivered by the ECB president and the Q&A session held with journalists. Reuters conducts polls for the median expected MRO multiple times for a specific quarter. We create a h quarter(s) ahead fixed event forecast from these polls. [9] High frequency surprises is sourced from Altavilla

[8]The transcripts of the ECB's monetary policy decisions can be found here.

[9]The polling dates are not necessarily close to the ECB's policy announcement date. In addition, the frequency of the polls for obtaining forecasts for MRO for a specific quarter varies over time. However, the latter is not of as much consequence as the gap between the polling date and the ECB's policy announcement

et al. (2019) which contains data on OIS yields and sovereign bonds.

date. A closer polling date will mean that the forecasters' information set of publicly available data will be more aligned with that of the ECB on the day of the Governing Council's meeting.

K.1 Target factor

Table K.17: Big surprises in target factor

Date	Surprise	Rate Δ	Current Economic Assessment	Potential reason for surprise
Nov 2002	1.85	0	Less than expected real GDP growth in Q3:2002 due to heightened uncertainty from "geopolitical tensions, evolution of oil prices and developments in stock markets". Inflation is close to 2% target.	Forecasters expected ECB to reduce rates due to subdued economic growth. A journalist commented, "Mr. Duisenberg, I think it is fair to say that you, the ECB, disappointed a lot of people today by not cutting interest rates."
Mar 2003	2.34	25bps ↓	Economic growth remained sluggish in previous months. Further, modest growth is expected in 2003 owing to geopolitical tensions and rise in oil prices. Inflation is likely to be on target in the medium term.	OIS yields rose at the short end of the yield curve. A journalist commented, "the markets have reacted somewhat badly to this rate decision and there seems to be some suspicion that it was a rather unhealthy compromise, possibly between those that wanted to cut by 50 basis points and those who maybe wanted to cut by 25 basis points or leave rates unchanged".
Jun 2008	1.63	0	Real GDP growth in the first half of the year was above expectations. Inflation was above 3% for several months and there were elevated risks to price stability over the medium term due to energy and food prices.	In the press conference, a journalist commented: "Markets are now, after your comments, pricing in a 65% chance of an increase in July, next month".
Oct 2008	-5.61	100bps ↓ MLF 50bps ↓ MRO with fixed tender	Collapse of large banks in the US led to heightened uncertainty about real GDP growth and inflation.	The large negative surprise occurred due to the unexpected decision of the ECB to cut policy rates on Oct 8 in response to the global financial market turmoil.
Nov 2008	5.16	50bps ↓	Financial market tensions cause a break in economic growth momentum. Prices and wages should moderate in light of weak domestic and global economy.	OIS yields rose despite a policy rate cut because there was an expectation of a larger rate cut, as in the case of the Federal Reserve and the Bank of England.
Aug 2011	-2.89	0	ECB concerned about deceleration in real GDP growth amidst heightened uncertainty. Inflation in the short term is a concern with upside risks to its medium term outlook.	Announcement of monetary easing measures such as continuing MROs at fixed rate until Jan 2012 and the Long-term Refinancing Operations at 3 months and 6 months maturity.
Oct 2011	4.69	0	Lacklustre economic growth due to slowing global demand, falling business confidence and deteriorating conditions in sovereign debt markets. Elevated inflation in previous months along with lacklustre growth.	Despite announcement of various policy measures such as Longer-term Refinancing Operations (LTRO) and Covered Bonds Purchase Programme (CBPP2), OIS yields rose. The median MRO forecast indicated an expected 25bps rate cut, but there was no change in the policy rate.
Nov 2011	-3.45	25bps ↓	Expectation of low real GDP growth due to sovereign debt crisis and slower global economic growth. Inflation is expected to decline from 3% in October to below 2% in 2012.	During the Q&A, the ECB president talked about the Euro Area "heading towards a mild recession by the end of the year". This would put downward pressure on prices, helping maintain price stability, and thereby allow the ECB to cut rates in order to aid economic growth.
Jul 2012	-2.79	25 bps ↓	Real GDP growth remains weak. Risks to higher inflation subsided due to a cooling of futures price of oil.	The ECB president pointed out that risks surrounding the economic outlook continue to be on the downside. Financial markets may have reacted to this negative information.
Sep 2014	-1.73	20 bps ↓	Real GDP growth saw a modest expansion but was weaker than expected. Inflation remained lower than the medium term target.	The ECB reduced policy rates and additionally announced purchase of non-financial private sector bonds and covered bonds.

K.2 Forward guidance factor

Table K.17: Big surprises in forward guidance factor

Date	Surprise	Rate Δ	Current Economic Assessment	Potential reason for surprise
Mar 2003	-1.85	25bps ↓	Economic growth remained sluggish in previous months. Further, modest growth is expected in 2003 owing to geopolitical tensions and rise in oil prices. Inflation is likely to be on target in the medium term.	ECB president reveals new set of forecasts where economic growth figures were revised downwards. This negative information may have reduced OIS yields.
Jun 2003	-2.98	50bps ↓	Economic growth remained very modest. Inflation is likely to decline below the 2% target due to sluggish demand and exchange rate appreciation.	Downgrade of real GDP growth forecast for 2003 prompted the ECB to provide a monetary stimulus.
Jul 2005	1.65	0	Economic growth remained subdued. Rising oil prices seem to be hampering demand and confidence. However, several indicators, such as favourable financial conditions and corporate earnings, point to a gradual recovery. Prices are stable around the 2% target.	Upside risks to inflation may have led markets to anticipate future increase in policy rate.
Jun 2008	2.64	0	Real GDP growth in the first half of the year was above expectations. Inflation was above 3% for several months and there were elevated risks to price stability over the medium term due to energy and food prices.	In the press conference, a journalist commented: "Markets are now, after your comments, pricing in a 65% chance of an increase in July, next month".
Jul 2008	-2.62	25bps ↑	Real GDP growth is likely to slow down in coming quarters. Inflation reached 4% in Jun 2008, well above the 2% target. High energy and food prices present an upside risk to price stability over the medium term.	In the press conference, the ECB president did not commit to future increase in the policy rate while markets had priced in a series of rate hikes.
Aug 2008	-2.21	0	Real GDP growth expected to be weaker in Q2:2008. Inflation remained well above the target with upside risks to price stability over the medium term.	The ECB's concern about economic growth prevented them from further increasing the policy rate. During the Q&A, a journalist asked, "Just a quick question. After this press conference investors will have certainly priced out any possibility of a rate increase this year and early next year. Are you comfortable with that?"
Mar 2011	1.84	0	Positive momentum in real GDP growth, although uncertainty is elevated. ECB flags upside risks to price outlook.	Staff projections for Mar 2011 signal an uptick in HICP inflation relative to Dec 2010. ECB signalled that rates may increase soon if the incoming data suggests that inflation will remain high.
May 2011	-1.47	0	Economic growth is on a positive trajectory since Q4:2010. Inflation rate is above target and under upward pressure from higher than expected fuel prices.	The ECB left the policy rate unchanged due to which markets reversed their bets of a policy rate hike.
Aug 2011	-1.44	0	ECB concerned about deceleration in real GDP growth. Inflation in the short term is a concern with risks to its medium term outlook on the upside.	Liquidity measures announced in the form of supplementary LTROs with 3 months and 6 months maturity. Additionally, MRO to be conducted at fixed rate until Jan 2012.
Dec 2016	1.49	0	Economic growth continued into Q4:2016. It was further expected to expand at a "moderate but firming pace". Inflation still below 2% target and will see a gradual recovery towards the 2% target.	Reduced pace of APP from 80 billion until Mar 2017 to 60 billion until the end of Dec 2017 or beyond, if necessary. Further, positive information about economic growth may have resulted in higher OIS yields.

K.3 Quantitative easing factor

Table K.17: Big surprises in quantitative easing factor

Date	Surprise	Rate Δ	Current Economic Assessment	Potential reason for surprise
May 2003	1.41	0	A review of monetary policy and communication.	N/A
May 2009	1.76	-25bps MRO -50bps MLF	Lack of global economic growth that is likely to remain subdued. Inflation was low primarily due to global commodity prices, but ECB expected to maintain medium-term price stability.	ECB president termed covered bond purchases as "enhanced credit support" and ruled out quantitative easing. This signalled that the ECB did not intend to target long term OIS yields with this programme.
Jan 2011	1.23	0	ECB worried about negative spillover of financial sector into the real economy. There is short term pressure on inflation, but price stability will be maintained over the medium term.	ECB president warned about upside risks to inflation and that rates may be raised despite ongoing economic conditions, reminding journalists about 2008 where the ECB raised rates during the economic slowdown. This hawkish tone raised medium and long term OIS rates.
Aug 2012	-1.35	0	Real GDP growth remained flat and was expected to remain weak. Inflation was expected to decline below the 2% target well into 2013. ECB additionally commented on irreversibility of the Euro.	The ECB commits to undertaking further non-standard measures for repairing monetary policy transmission in the Euro Area, the modalities of which would be announced in coming weeks.
Feb 2013	-1.34	0	QoQ EA real GDP growth contracting since H2:2012 and likely to stay weak. Loan growth to non-financial sectors also remained negative. Prices hovering around 2% target.	There were downside risks to economic outlook while risks to price outlook was broadly balanced.
Jan 2015	-1.76	0	Lacklustre economic growth accompanied with low credit growth. In addition, weak inflation dynamics due to fall in energy prices.	Extended Asset Purchase Programme (APP) announced. Targeted LTRO pricing to be reducced by removing spread over MRO.
Oct 2015	-1.43	0	Real GDP growth continued its recovery in 2015, but was likely to decline owing to weaker foreign demand. Inflation remained near zero, but was expected to rise due to base effects.	ECB credits asset purchases with reducing cost of borrowing for firms and households in the Euro Area. Reaffirmation of APP to run till Sep 2016.
Dec 2015	3.44	10 bps↓ EDF	ECB:"Today's decisions were taken in order to secure a return of inflation rates towards levels that are below, but close to, 2% and thereby to anchor medium-term inflation expectations."	APP extended till Mar 2017. Journalist asks in the Q&A,"You've just explained your reasoning, but nevertheless, financial markets appear to be disappointed".
Dec 2016	-1.24	0	Economic growth continued into Q4:2016. It was further expected to expand at a "moderate but firming pace".	Reduced pace of APP from €80 billion until Mar 2017 to €60 billion until the end of Dec 2017 or beyond, if necessary. However, ECB committed to increasing the pace if the outlook becomes less favourable, or if financial conditions become inconsistent.
Jun 2018	-1.42	0	Slow, but broad based real GDP growth. Inflation is likely to remain below 2%, but expected to increase towards the end of the year.	Pace of APP to continue at €30bn. ECB provided a roadmap for reducing pace of asset purchases. Further, it provided date and state dependent forward guidance on policy rates.

K.4 Asymmetric country risk factor

Table K.17: Big surprises in asymmetric country risk factor

Date	Surprise	Rate Δ	Current Economic Assessment	Potential reason for surprise
Aug 2011	1.97	0	ECB concerned about deceleration in real GDP growth. Inflation in the short term is a concern with risks to its medium term outlook on the upside.	Longer-term refinance operations (LTRO) with three and six months maturity. MRO to continue to be conducted at fixed rate with full allotment till Jan 2012. However, none of these announcement reduced sovereign spreads that were already high since the EU summit on Jul 21
Dec 2011	3.14	25bps ↓	Dampened economic growth as well as outlook due to financial market tensions. Going forward, downward revision in 2012 real GDP growth.	Introduced liquidity enhancing measures to improve financial conditions. These included a three year LTRO, reducing the rating threshold for certain asset-backed securities (ABS) and reducing reserve ratio. Despite these assurances, yield spread increased.
Jul 2012	3.28	25 bps ↓	Real GDP growth remained weak. Risks to higher inflation were subsiding.	ECB president pointed to tensions in some euro area sovereign debt markets. However, no additional measures were discussed by the Governing Council to tackle fragmentation in financial markets.
Aug 2012	6.21	0	Real GDP growth remained flat and is expected to remain weak. Inflation is expected to decline below the 2% target well into 2013. ECB additionally commented on irreversibility of the Euro, "Risk premia that are related to fears of the reversibility of the euro are unacceptable, and they need to be addressed in a fundamental manner. The euro is irreversible.".	Italian and Spanish yields jumped higher during the press conference while German yields declined.
Sep 2012	-3.18	0	Economic growth remained weak, inflation above 2%, but likely to subside in the medium term. Heightened uncertainty in financial markets.	Introduced Outright Monetary Transactions (OMT) for secondary bonds, "OMTs will enable us to address severe distortions in government bond markets which originate from, in particular, unfounded fears on the part of investors of the reversibility of the euro". This announcement was effective in reducing sovereign bond spreads.
Jan 2013	-1.74	0	Economic weakness in the euro area was expected to continue well into 2013. Inflation declined from summer of 2012, owing to a cooling of oil prices.	ECB highlighted that accommodative monetary policy will further reduce fragmentation. Moreover, it is "not thinking about an exit" for non-standard policies that were introduced to reduce fragmentation in Euro Area financial markets.
Jul 2013	-3.10	0	Economic growth, labour market, credit expansion remain subdued. There was an emergence of a few green shoots of economic growth. Inflation is likely to remain below 2%.	ECB focussed on improving transmission of monetary policy by further reducing fragmentation of Euro Area credit markets.
Dec 2015	2.17	10 bps↓ in EDF	ECB:"Today's decisions were taken in order to secure a return of inflation rates towards levels that are below, but close to, 2% and thereby to anchor medium-term inflation expectations."	A journalist in the Q&A asked, "You've just explained your reasoning, but nevertheless, financial markets appear to be disappointed". There was a big sell-off in bond markets with Italian and Spanish yields increasing more than the German yields.
Jun 2018	-2.41	0	Slow, but broad based real GDP growth. Inflation is likely to remain below 2%, but expected to increase towards the end of the year.	ECB stresses that the situation in sovereign bonds is localized and not as extreme as the 2011 episode associated with redenomination risk. Sovereign yields of Italy declined more than all other major member countries.
Sep 2019	-1.98	10 bps ↓	Inflation remains far from the 2% target. Outlook for real GDP growth and inflation revised downwards.	ECB additionally restarted the Asset Purchase Programme (APP). Italian and Spanish yields declined while French and German yields increased.

References

Altavilla, C., L. Brugnolini, R. S. Gürkaynak, R. Motto, and G. Ragusa (2019). Measuring euro area monetary policy. *Journal of Monetary Economics 108*, 162–179.

Forni, M., L. Gambetti, and G. Ricco (2022). External instrument svar analysis for noninvertible shocks.

Gürkaynak, R. S., B. Sack, and E. Swanson (2005, May). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking 1*(1).

Jarociński, M. and P. Karadi (2020, April). Deconstructing monetary policy surprises–the role of information shocks. *American Economic Journal: Macroeconomics 12*(2), 1–43.

Kerssenfischer, M. (2022). Information effects of euro area monetary policy. *Economics Letters 216*, 110570.

Miranda-Agrippino, S. and G. Ricco (2021, July). The transmission of monetary policy shocks. *American Economic Journal: Macroeconomics 13*(3), 74–107.

Motto, R. and K. Özen (2022, February). Market-stabilization QE. Working Paper Series 2640, European Central Bank.

Stock, J. H. and M. W. Watson (2010). Monthly gdp and gni–research memorandum. *Manuscript, Princeton University*.

Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics 118*, 32–53.